GRAND ERUPTION OF VESUVIUS 1767.

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NATURE DISPLAYED

IN THE

HEAVENS,

AND

ON THE EARTH,

ACCORDING TO THE LATEST

OBSERVATIONS AND DISCOVERIES.

BY SIMEON SHAW, L. L. D.

From the birth
Of human kind, the sov'reign Maker said,
That not in humble, nor in brief delight,
Not in the fleeting echoes of renown,
Power's purple robes, nor Pleasure's flowery lap,
The soul should find contentment; but, from these
Turning disdainful to an equal good,
Through Nature's opening walks enlarge her aim,
Till every bound at length should disappear,
And INFINITE PERFECTION fill the scene.

AKENSIDE.

IN SIX PARTS.

PART II.

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GENERAL ORDER OF STRATA;—AND SECTION OF THE BROCKEN MOUNTAIN.

These two engravings afford a clear notion of the general order of the rocks and strata which compose the surface of the earth.—The granite is the lowest or central formation; but, in the structure of mountains, it is the highest, or the centre and nucleus, buttress or bulwark of the mountain, the other rocks and strata lying obliquely against and upon it. This would be intelligible if we were to consider the moon as formed entirely of granite, and that the earth was once like the moon, the surface being irregularly formed like that of the moon: some successive causes, about which various hypotheses have been raised by speculative men, have then produced the upper layers or strata, till we arrive at the most recent or uppermost stratum, called *alluvium*, which, according as the subdivisions and mode of numbering, may be considered as No. 1 or No. 17 in the two plates.

STRATA OF HEADEN HILL, ISLE OF WIGHT.

This hill, and its neighbouring parts on the right, exhibit a striking, but not uncommon, instance of the revolutions to which the materials of the earth's surface have been subject. The hill itself is composed of strata in the natural horizontal position; but the cliffs to the right in Allum Bay, though composed of similar strata, present them in a perpendicular direction, although like the others.

V on the extreme light consists of yellow and white sand with grey stripes.

W is formed of five beds of coal.

X is whitish sand, with stripes of deep yellow.

Z consists of layers of water-worn black flint pebbles, imbedded in yellow sand.

B is a stratum of blackish clay, containing green earth and fossil shells, worn down towards C by a stream of fresh water.

C consists of yellowish sand inclined 45 degrees.

D is also inclined when it is in contact with C, but afterwards stretches horizontally and forms a sandy base to the incumbent hill.

The whole have evidently been formed at the bottom of the ocean. The strata in the hill are indicated in the plate; but in the middle are three beds of coal, palpably of vegetable origin, as fruits and branches are still observed in it.

CURVED GNEISS IN LEWIS.

This remarkable specimen of gneiss in a curved state, copied from Dr. M'Culloch's work on the Hebrides, proves that it must once have been elastic; while the characters of this and other primitive mountains demonstrate that the change must have been produced by fire, previously to the formation of the secondary rocks.

Gneiss is the rock in which metals most abound, and is itself a compound of felspar, quartz, and mica, and of a slaty character, as is evident from the terminations of this enormous specimen. It would seem as though the action of water had in certain places carried off the alluvion, and left the primitive rocks bare; and that this specimen of gneiss must in some remote age have been covered with other strata.

SECTION OF THE LAND FROM DONCASTER TO MACCLESFIELD; AND ALSO FROM NEWCASTLE TO LONDON.

The writing upon this plate sufficiently explains the subjects. The first correct notions in regard to the successive battening or rising of different strata, by which a surface of country exhibits so regular a diversity of soils, were promulgated by Mr. W. Smith, and published in his geological map of England. These examples are copied from originals obligingly contributed to the editor for the use of this work. It would appear that the inclination of some primitive mountain has served as a basis to these strata, and governed their inclinations, and that they have been laid one over the other against the mountain by successive actions of the sea. To avoid confusion, the angles of the strata, as they rise to the surface, are, however, considerably too large. One great use of this knowledge is the certainty which it affords that, by digging to a certain depth, we shall arrive at certain desired strata.

THE GREAT ERUPTION OF VESUVIUS OF 1767.

This splendid engraving, perhaps the most effective which ever represented this great phenomenon of nature, was published by Sir W. Hamilton in the Philosophical Transactions. It represents the eruption of 1767, and the burning lava is seen rolling down the sides of the cone and the adjacent mountain towards cultivated and inhabited districts. This eruption is reckoned the 27th since that which destroyed the cities of Herculaneum and Pompeii, in the reign of the emperor Titus.

COLUMN OF SMOKE FROM VESUVIUS IN 1794.

This representation of a wonderful phenomenon was also published by Sir William Hamilton, in the Philosophical Transactions. It was determined by observation that the column of dense black smoke on this occasion ascended to the height of nearly thirty miles, darkening all the atmosphere behind it. Indeed, its ascent was so great that it seems to falsify the common theories in regard to the increased rarity of the atmosphere, which must at any rate have been greater than that of the smoke, to hold it in suspension; the smoke, being a conductor of electricity, evidently connected the electrified strata of the atmosphere, and hence lightning took place within the mass. On this occasion scoriæ were projected or carried by the wind to the distance of two hundred miles, and scattered over the country in the intermediate space. Nothing can give a more correct notion of the sublime character of a volcano than this engraving and the other which precedes it.

VESUVIUS AFTER THE ERUPTION OF 1794.

This is an accurate engraving, from a drawing made under the direction of Sir William Hamilton, of the actual appearance of the crater after the eruption of 1794.

SMALL VIEW OF THE ERUPTION OF 1794.

This engraving is also copied from Sir William Hamilton, and conveys a picturesque idea of the eruptions of this mountain as viewed across the bay of Naples.

INTERIOR OF THE CRATER OF VESUVIUS.

A View of the interior of the crater, as drawn on the spot after the eruption of 1805.

VIEWS OF ETNA.

Mount Etna, as taken by modern observations, is 11,000 feet high, though M. Gourbillon, a scientific traveller, asserts that it is double that height; but probably he meant the hypothenuse and not the perpendicular height. The crater is a vast aperture, having four summits of different heights, and is more than a mile in width, and about four miles in circumference. It is divided into two craters, by a cone rising from its centre, and a small one which has probably been formed within a recent period, from whence smoke in great quantities constantly issues.

Although no great eruption has taken place at Etna for many years, yet its internal fires are not extinguished, and indicate great activity, causing concussions which have from time to time alarmed the inhabitants of Catania, and even overthrown some houses.

One of the views of the crater was recently taken by M. Montulé; the other is from Sir Wm. Hamilton; and another is from Brydone. We have multiplied them because the craters of volcanoes are objects of the highest mundane curiosity, and their changeable character renders different views necessary. All volcanoes appear to agree in having a large crater or cauldron of melted lava in the middle, with one or more orifices, round which accumulate a cone of ashes and lava; these we have variously depicted. Some travellers have paid the forfeit of their lives by the indulgence of their rash curiosity in seeking a peep into these gulphs of smoke and sulphur.

All they have been able to effect has been to describe the heat of the ground, the scorching of their boots, and the horrible desolation of the scene. Dr. Watson imitated them by burying a paste made of water, sulphur, and iron filings; and hence it has been supposed that the sea communicates with such materials in the bowels of Etna and Vesuvius. This hypothesis does not accord, however, with positions of the South American volcanoes, unless we are to suppose that the accumulated snow effects the same purpose as the sea in other cases. The earthquakes produced through the adjoining country during eruptions appear to prove that the explosions are deeply seated; but it continues to be a question whether they reach below the granitic formation; if they do so, their depth may exceed what has hitherto been imagined.

A VIEW OF THE CRATER OF ETNA.

M. Gourbillon, the last traveller who has published a description, states that the main gulph includes four distinct abysses or craters: the south crater (extinct); the eastern, or great crater; the northern crater; and the western crater, the nearest to the centre of the gulph. Besides the bank round the gulph, each crater has its own bank. The eastern crater is as large as that of Vesuvius, being above a mile round. Some pieces of lava were thrown down it, which sounded after a few seconds. M. G. descended 200 feet into the eastern crater, and with difficulty avoided falling into its abyss. The interior is covered with very fine, light, grey sand. From the northern crater smoke arose, and the heat was overpowering. The western crater is too dangerous for descent, and great noises are heard within it. A new crater was formed in 1819, which burnt with great fury during that year.

VOLCANO OF STROMBOLI.

This is one of the Lipari Isles, lying north of Sicily. It is a mountain with two summits: the highest is about a mile high. The burning crater is about half-way up, on the NW. side of the mountain, and has a diameter of 250 feet. Burning stones are thrown up, at intervals of seven or eight minutes, ascending in diverging rays. The present crater has burned more than a century, without any apparent change of phenomena.

HECLA.

Hecla, one of the most active volcanos now known, as well as the most northern, is situated in a very desolate region of the earth; the approach to it is so impracticable that few travellers have had the hardihood to make the attempt. The engraving conveys some idea of the ruggedness of the district.

The cone of the mountain is 5000 feet above the level of the sea, by which the base is washed. The accumulated ice at its foot, and the noise which its crashing creates, united to the roaring of the mountain, lead the superstitious among the northern nations to regard Hecla as the mouth of Hell; and English seamen have been known to become the dupes of such fancies.

MARINE VOLCANO AT ST. MICHAEL'S.

Approaching the island of St. Michael's, (says Capt. Tillard,) on Sunday, the 12th of June, 1811, in the sloop Sabrina, we occasionally observed, rising in the horizon, two or three columns of smoke. Imagine an immense body of smoke rising from the sea, the surface of which was marked by the silvery rippling of the waves, occasioned by the light and steady breezes incidental to those climates in summer. In a quiescent state, it had the appearance of a circular cloud, revolving on the water like an horizontal wheel, in various and irregular involutions, expanding itself gradually on the lee-side; when suddenly a column of the blackest cinders, ashes, and stones, would shoot up in the form of a spire, at an angle of from ten to twenty degrees from a perpendicular line, the angle of inclination being universally to windward; this was rapidly succeeded by a second, third, and fourth shower, each acquiring greater velocity, and overtopping the other, till they had attained an altitude as much above the level of our eye, as the sea was below it. As the impetus, with which the columns were severally propelled, diminished, and their ascending motion had nearly ceased, they broke into various branches, resembling a groupe of pines!—These again, forming themselves into festoons of white feathery smoke, in the most fanciful manner imaginable, intermixed with the finest particles of falling ashes, which at one time assumed the appearance of innumerable plumes of black and white ostrich feathers surmounting each other; at another, that of the light wavy branches of a weeping willow. During these bursts, the most vivid flashes of lightning continually issued from the densest part of the volcano; and the cloud of smoke, now ascending to an altitude much above the highest point to which the ashes were projected, rolled off in large masses of fleecy clouds, gradually expanding themselves before the wind, in a direction nearly horizontal, and drawing up to them a quantity of water-spouts, which formed a most beautiful and striking addition to the general appearance of the scene. In less than half an hour a peak was plainly visible above the water; and, about three hours from the time of our arrival, a complete crater was formed above the water, not less than twenty feet high on the side where the greatest quantity of ashes fell; the diameter of the crater being apparently about 400 or 500 feet. The great eruptions were generally attended with a noise like the continued firing of cannon and musketry intermixed, as also with slight shocks of earthquakes. Now one of the most magnificent bursts took place which we had yet witnessed, accompanied by a very severe shock of an earthquake. In an instant we observed a large portion of the face of the cliff, about fifty yards on our left, falling, which it did with a violent crash. At night the volcano seldom emitted any lightning, but occasionally as much flame as may be seen to issue from the top of a glass-house or foundery chimney. On passing directly under the great cloud of smoke, about three or four miles distant from the volcano, the decks of the ship were covered with fine black ashes, which fell intermixed with small rain. On opening the volcano clear of the north-west part of the island, after dark, on the 16th, we witnessed one or two eruptions. On the 4th of July we approached the volcano, and perceived that it was still smoking in many parts; and, upon our reaching the island, found the surf on the beach very high. On landing, we found a narrow beach of black ashes, from which the side of the island rose in general too steep to admit of our ascending; and, where we could have clambered up, the mass of matter was much too hot to allow of our proceeding more than a few yards in the ascent The most extraordinary part was the crater; the mouth of which, on the side facing St. Michael's, was nearly level with the sea. It was filled with water, at that time boiling, and was emptying itself into the sea by a small stream about six yards over, and by which I should suppose it was continually filled again at high water. The island has gradually disappeared from October 1811, leaving an extensive shoal on the spot; but smoke continued issuing out of the sea through February 1812.

SUBTERRANEOUS CONFLAGRATION IN JAPAN.

The engraving conveys some idea of this catastrophe. 1. The mountain Asama. 2. Kousats-yama, where the fire commenced. 3. A post which marks the boundaries of the provinces Sinano and Koutsouki. 4. A village at the foot of the mountain, but ten miles distant from its summit. 5. The village of Orprake, where there are hot springs. 6. A mountain, twenty miles from Kousats-yama.

In September 1783, dreadful ravages were occasioned by the eruption of the volcano Asama-ga-daki, says M. Titsing, in his curious work on Japan. At eight o'clock one morning, there arose, in the province of Sinano, a very strong east wind, accompanied by a dull noise, like that of an earthquake, which increased daily. In four days there was a tremendous noise, and a shock of an earthquake: the walls of the houses cracked, and seemed ready to tumble. Each successive shock was more violent, till flames burst forth, with a terrific uproar, from the summit of the mountain, followed by a tremendous eruption of sand and stones. Though it was broad day, every thing was enveloped in profound darkness, through which the flames alone threw at times a red light. For three days the mountain never ceased to cast up sand and stones. The large village of Sakamoto, and several others, situated at the foot of the volcano, were soon reduced to ashes, by the ignited matter which it projected, and by the flames which burst from the earth. The inhabitants fled; but the chasms, every where formed by the opening of the ground, prevented their escape, and in a moment a great number of persons were swallowed up or consumed by the flames. The water of the rivers Yoko-gawa and Carousawa boiled; the course of the Yone gawa, one of the largest rivers of Japan, was obstructed; the boiling water inundated the adjacent country; and there fell a shower of red-hot stones, each weighing four or five ounces. The bears, hyænas, and other beasts of prey, fled from the mountains, and flocked to the neighbouring villages, where they devoured the inhabitants, or mangled them in a horrible manner. The number of dead bodies floating upon the rivers was incalculable. Twenty-seven villages were swallowed up.

EARTHQUAKE IN CALABRIA.

This little engraving, copied from an Italian print, represents the extraordinary overturning of several fields in that country, during the great earthquake in 1783. They were thrown up into the oblique position represented, with all their trees and other objects upon them, exhibiting their strata to a considerable depth. This accounts for faults in strata, and such appearances as at Headon Hill, &c. &c.

SCALE OF THE NEWCASTLE STRATA.

This engraving accurately exhibits the successive strata from the surface of the earth to the depth of 135 fathoms in the Newcastle coal district. It indicates the progressive operations which have taken place on the surface of the earth at intervals of distant ages. For, as there seems no doubt that the coal consists of forests in a fossil state, so each bed of coal must have been a submerged forest; and the intermediate strata washed or rolled upon them, and formed into its peculiar character by chemical combinations, and exudations, from pressure, and lengthened pressure.

THE LEINSTER COAL DISTRICT.

This engraving will convey a more accurate idea of the strata of the earth than a hundred verbal descriptions. We are indebted for it to the interesting and scientific work of Mr. Griffith. The characters of the several strata are indicated by the lines in which they are engraved, as may be seen in the scale at the left-hand corner. The mountain stands on a basis of lime-stone, distinguished by the waving lines, and of course the whole of the upper strata have been formed since the lime-stone. Immediately above the lime-stone is a stratum of black slate-clay; then a stratum of sand-stone from 25 to 50 feet in thickness; then another of slate-clay; and these alternate with some mixtures, so that in the mountain there are no less than 16 beds of sand-stone and 11 of slate-clay; the others consisting, as may be observed, of seven of slaty sand-stone, of two of fire-clay, with one of coal lying over it.

But, by one of those caprices which belong to all formations, we have on the right two other coal formations, also upon fire-clay, and these formations appear as though they had extended higher, and joined the small bed of coal near Upper Firoda. The regular thickness of the strata in this mountain, the uniformity of the series contrasted with the serpentine directions into which they are thrown, and the extraordinary manner in which they are discontinued at the surface, as evident parts of continued curves, fill the mind with unsatisfied curiosity in regard to the original production, and the cause of its present broken condition.

CRYSTALLIZATION.

As all matter must consist of primeval atoms, so these, in combination, must assume determinate regular forms. If small enough, they may be spherical, and yet form regular bodies, as triangles, when ten, six, or three, are put together; when one is put upon three, a tetrahedron; and six would form an octahedron; while seven would form an acute rhomboid. Hence, all compounded forms, which may be the small bodies producing sensible phenomena, may consist of spherical atoms, provided these are sufficiently small; but, as such atoms would require cement, this hypothesis, for which Dr. Wollaston has taken credit, seems to be necessarily wrong. Better is it to conceive with Haüy, that primary atoms are in three different forms, as cubes, tetrahedra, and prisms; which three compounded form octahedra, hexangular prisms, dodecahedrons, and acute rhomboids; because herein we have that union of sides, which, when packed, are not easily disturbed, and exhibit the various phenomena of cohesion. Chemical action is then easily explained by the application of heat, or atomic motion in any form, as in gases or fluids; and then the introduction of an agent of a dissimilar form of atoms necessarily decomposes any mass of similar shaped atoms. Haüy illustrates his very ingenious theory, by supposing that the six secondary forms may arise from decrements of particles on different edges and angles of the three primitive forms. Thus, if a cube has a series of decreasing layers upon each of its six sides, it becomes a dodecahedron, as in fig. 1, if the decrement be upon the edges; but an octahedron, if upon the angles; while, by varying the decrements in different layers, an infinite variety of forms may be produced, as in fig. 1 and 2, which is ingenious and satisfactory. The nature of chemical action, or repulsion, will be evident, if, within such a mass of cubes as fig. 1 or 2, a number of tetrahedra were introduced, or made to insinuate themselves by heat or atomic motion

Of course, they would disturb the order of the layers, and decompose the whole mass. Fig. 3 and 4 exhibit the chemical and mechanical action of fluids and chemical agents on certain solids, in some ingenious experiments made by Mr. Daniell. Many analogies support the idea of three primitive forms of atoms, such as the three principal gases, oxygen, nitrogen, and hydrogen; the three colours,—red, yellow, and violet; and the three primary tones in music; while their combinations produce intermediate varieties of phenomena.

The figures in Plate I. represent the regular forms which the Abbé Haüy considers, and with apparent justice, as that of primæval atoms which constitute the basis of all solid matter, and which therefore are objects of the highest curiosity, in a philosophical point of view. One of the figures shows how solids may consist of an aggregation of little cubes, producing a figure in large similar to their own.

The Second Plate exhibits some experiments made by applying acids to solids, which, when examined by the microscope, appear to be separated in layers and regular forms, and not in the irregular manner which the cursory observations of the naked eye might lead us to imagine. The figures made up of balls are given in support of the hypothesis of Dr. Wollaston, who considers the primary atoms of matter as spherical, and that the regular forms of Haüy are necessary results of the primary atoms being spheres. —The idea is ingenious, but it suits the construction of fluids better than that of solids, and seems to require that the density of all solids should be similar, while it prevents the cohesion from contact.

THE MOUNTAINS ON THE EARTH.

The following enumeration serves as a Key to the interesting Engraving of the principal Mountains, &c. throughout the world:

WESTERN HEMISPHERE.

Explanation of the Figures and Letters.

Figures.	Mountains, &c.	Lat.	Country.	Feet above the sea.
1.	Town of Leon de Caraccas	$10\frac{1}{2}$°N.	S. America.	3,490
2.	The Intendency of Mexico, and parts of the adjoining provinces, lying on the high table land of New Spain	$19\frac{1}{2}$ N.	New Spain.	7,500
3.	Town of Riobamba		Peru.	11,670

4.	The lake of Toluca	$19\frac{1}{4}$ N.	Mexico.	12,195
5.	Popocatepetl, the highest mountain in Mexico, a volcano	$18\frac{1}{2}$ N.	Mexico.	17,720
6.	Chimborazo, the highest peak of the Andes	$1\frac{1}{2}$ S.	Quito.	21,440
	⁎ In the text Humboldt speaks of 3000 yards—but he means from the elevated plain on which the cone is situated.			
7.	Cotopaxi, a volcano in the Andes, remarkable for the frequency and violence of its eruptions		Quito.	18,898
8.	Cajambe, a peak of the Andes		Quito.	19,480
9.	Antisana, a volcanic summit of the Andes		Quito.	19,150
10.	Tonguaragua, a volcano		Quito.	16,270
11.	Real del Monte, a mine	$19\frac{1}{4}$ N.	Mexico.	9,125
12.	Cotocatche, a peak of the Andes	$1\frac{1}{2}$ S.	Quito.	16,450
13.	Imbabura, a volcano, which frequently ejects fish	1 S.	Quito.	8,960
14.	Mount St. Elias, the highest mountain in North America	$60\frac{1}{3}$ N.	N. W. Coast	18,090
15.	Height of Assuay, the ancient Peruvian road			15,540
16.	The city of Quito	$0\frac{1}{2}$ S.	Quito.	9,630
17.	Peaks of the Rocky mountains		N. America.	6,250
18.	The Farm House of Antisana, the highest inhabited place on the surface of the globe. It is elevated, according to Humboldt, 3,800 feet above the plains of Quito			13,500
19.	Pambomarca, a summit of the Andes	$0\frac{1}{2}$ S.	Quito.	13,500
20.	Jorullo, a volcano	19 N.	Mexico.	4,265
21.	La Souffriere, a volcano		Guadaloupe.	5,500
22.	The north peak of the Blue mountains in Jamaica	13 N.	W. Indies.	8,180
23.	The height attained by Humboldt and Bompland in June, 1802, and the highest spot of earth on which man ever trod. These enterprising travellers attempted to ascend to the top of Chimborazo, but were prevented by a chasm 500 feet wide. At the height to which they attained they found the air intensely cold and piercing, and, owing to its extreme tenuity, respiration was difficult. The blood oozed from the eyes, lips, and gums. One of the party fainted, and all of them felt extreme weakness			19,400
24.	The highest flight of the Condor			21,000
a.	The highest limit of the lichen plant			18,225
b.	Lower limit of perpetual snow under the equator			15,730
c.	The highest limit of pines under the equator			12,800

d. The highest limit of trees under the equator	11,125
e. The highest limit of oaks under the equator	10,500
f. The highest limit of the Peruvian bark tree	9,500
g. Lowest limit of pines under the equator	5,685
h. Highest limit of palms and bananas	3,280

Mountains, &c. not referred to by figures.

Mountains, &c.	Lat.	Country.	Feet above the sea.
The peak of Orizaba, a volcano	19° N.	Mexico.	17,370
Iztaccihuatl	19 N.	Mexico.	15,700
Nevada de Toluca	19¼ N.	Mexico.	15,165
Nauhcampatepetl	19½ N.	Mexico.	13,415
Highest peak	40¼ N.	Missouri.	12,500
James peak	38¾	Do.	12,000
Mount Fairweather, near Mount St. Elias on the N. W. coast of N. America	59 N.		8,970
The city of Santa Fe de Bogota	4½ N.	S. America.	8,615
Mount Washington, the highest peak in the United States	44¼ N.	N. Hampshire.	6,634
The city of Popayan	2½ N.	S. America.	5,825

EASTERN HEMISPHERE.

Figures.	Mountains, &c.	Lat.	Country.	Feet above the sea.
1.	The Dholager or Dhawalagiri, the highest summit of the Himmalaya mountains, which form the boundary between Hindostan and Thibet	29° N.	Thibet.	27,677
2.	Yamunatri or Jamautri, another peak of the Himmalaya range	29 N.	Thibet.	25,500
3, 4, 5, 6, and 7,	are also summits of the Himmalaya mountains, varying in height from 22,400 to 24,600 feet.			
8.	Mont Blanc, the highest summit of the Alps	46 N.	Italy.	15,665
9.	Mont Rosa		Switzerland.	15,540
10.	Mont Cervin, Pennine Alps		Switzerland.	14,780
11.	Mont Pelvoux		France.	14,215
12.	Mount Ophir, in Sumatra		Sumatra.	13,842
13.	Jungfrau, a peak of the Alps	40½ N.	Switzerland.	13,735
14.	Mount Ozon, a peak of the Alps		France.	13,465
15.	Finsteraarhorn, Alps		Switzerland.	13,234

16. Sochonda mountains	49	N.	China.	12,800
17. Peak of Teneriffe	28½	N.	Canaries.	12,176
18. Mulahacan	37	N.	Spain.	11,670
19. Schreckhorn, a peak of the Alps	46½	N.	Switzerland.	11,490
20. Peak of Venletta	37	N.	Spain.	11,390
21. Mont Perdu, the highest of the Pyrennees	42¾	N.	France.	11,265
22. Le Vignemai	42¾	N.	Do.	11,010
23. Mount Etna	37½	N	Sicily.	10,955
24. Mount Furca, in the Alps	46½	N.	Switzerland.	10,850
25. Pic Blanc, Alps	45¾	N.		10,203
26. Mount Lebanon	35	N.	Syria.	9,535
27. Mount St. Gothard			Switzerland.	8,930
28. Peak of Lomnitz, the highest of the Carpathian mountains	49	N.	Hungary.	8,640
29. Mont Velin, the highest of the Appenines	42½	N.	Italy.	8,300
30. Sneebutten	62½	N.	Norway.	8,295
31. Convent on Mount St. Bernard	46	N.	Switzerland.	8,040
32. A volcano in Bourbon	21½	S.	Ind. Ocean.	7,680
33. Pilatusberg, in the Alps			Switzerland.	7,080
34. Convent of St. Gothard			Switzerland.	6,810
35. Mount Cenis	45½	N.	Italy.	6,780
36. Mount Olympus	40	N.	Turkey.	6,500
37. Mont d'Or	45¼	N.	France.	6,190
38. The Cantal, in the same chain	45	N.	Do.	6,090
39. Mont Reculet, Jura chain			Switzerland.	5,590
40. Puy de Dome, in Auvergne	45¾	N.	France.	5,225
41. Hecla	64	N.	Iceland.	5,010
42. Mount Ida	35¼	N.	Candia.	4,960
43. Snoe Fiall	65	N.	Iceland.	4,560
44. Ben Nevis, the highest in Great Britain	56¾	N.	Scotland.	4,370
45. The town of Briancon	45	N.	France.	4,270
46. Cairngorm	57	N.	Scotland.	4,066
47. Mount Vesuvius	40¾	N.	Italy.	3,935
48. Palace of St. Ildefonso	41	N.	Spain.	3,790
49. Ben Wyvis	57¼	N.	Scotland.	3,720
50. Snowdon, in Wales	53¼	N.	Wales.	3,571
51. Ben Lomond	56¼	N.	Scotland.	3,250
52. Madrid	40½	N.	Spain.	2,276
53. Rock of Gibraltar, highest part	36	N.	Spain.	1,440
54. Arthur's Seat, near Edinburgh			Scotland.	809
55. London, at St. Paul's	51½	N.	England.	65
56. Dover Castle (in Kent)	51	N.	England.	469
57. Wrekin (Shropshire)	52¾	N.	England.	1,320
58. Holyhead mountain			Wales.	709
59. Dundry beacon (Somersetshire)	51½	N.	England.	1,668
60. Plynlimmon	52½	N.	Wales.	2,463
61. Paris	48¾	N.	France.	115
62. Pyramids of Egypt	30	N.	Egypt.	500

63.	Lake of Constance	$47\frac{1}{2}$ N.	Switzerland.	1,162
64.	The highest flight of a balloon. Gay Lussac ascended to this height !			22,900
65.	Greenwich Observatory	$51\frac{1}{2}$ N.	England.	214
i.	Perpetual snow in Switzerland, above the altitude of 8,000, or			9,000
k.	Perpetual snow at this altitude, in		Norway.	7,000

*** Such are the admitted average heights of Mountains, but different Travellers report differently, and hence in every two tables and reports the elevation varies.

CHIMBORAZO AND COTOPAXI.

Chimborazo is 21,000 feet above the level of the sea, and 9000 above the elevated plains on which they stand; and Cotopaxi, 19,000. Till the discovery of the Himalayas, they were considered the highest points on the globe.

We distinguish, says Humboldt, three kinds of principal forms belonging to the high tops of the Andes: the volcanoes which are yet burning; volcanoes, the summits of which have sunk after a long series of eruptions, exhibiting ridges bristled with points, needles leaning in different directions, and broken rocks falling into ruins; and a third form of the high tops of the Andes, and the most majestic of the whole, is that of CHIMBORAZO, the summit of which is circular. The aspect of mountains of granite has little analogy with that of Chimborazo. Granite summits are flattened hemispheres, and the trappean porphyry forms slender cupolas: but Chimborazo appears like a cloud at the distance of 200 miles. It detaches itself from the neighbouring summits, and towers over the whole chain of the Andes, like that majestic dome produced by the genius of Michael Angelo, over the antique monuments which surround the Roman Capitol.

The bulk of Chimborazo is so enormous, that the part which the eye embraces at once, near the limit of the eternal snows, is 8000 yards in breadth. The extreme rarity of the strata of air, across which we see the tops of the Andes, contributes, too, greatly to the splendour of the snow, and the magical effect of its reflection. Under the Tropics, at a height of 6000 yards, the azure vault of the sky appears of an indigo tint. The outlines of the mountain detach themselves from the sky in this pure and transparent atmosphere; while the inferior strata of the air, reposing on a plain destitute of vegetation, which reflects the radiant heat, are vaporous, and appear to veil the middle of the mountain.

Cotopaxi is the loftiest of the volcanoes of the Andes, which at recent epochs have undergone eruptions; and, notwithstanding it lies near the Equator, its summits are covered with perpetual snows. The absolute height of Cotopaxi is 18,876 feet, or these miles and a half; consequently it is 2,622 feet, or half a mile, higher than Vesuvius would be, were that mountain placed on the top of the Peak of Teneriffe! Cotopaxi is the most mischievous of the volcanoes in the kingdom of Quito, and its explosions are the most frequent and disastrous. The masses of scoriæ and the pieces of rock thrown out of this volcano cover a surface of several square leagues, and would form, were they heaped together, a prodigious mountain. In 1738, the flames of Cotopaxi rose 3000 feet, or upwards of half a mile, above the brink of the crater. In 1744, the roarings of this volcano were heard at the distance of 600 miles. On the 4th of April, 1768, the quantity of ashes ejected at the mouth of Cotopoxi was so great, that it was dark till three in the afternoon. The form of Cotopaxi is the most beautiful and regular of the colossal summits of the high Andes. It is a perfect cone, which, covered with a perpetual layer of snow, shines with dazzling splendour at the setting of the sun, and detaches itself in the most picturesque manner from the azure vault above. This covering of snow conceals from the eye of the observer even the smallest nequalities of the [illegible]; no point of rock, no stony mass, penetrating this coat of ice, or breaking the regularity of the figure of the cone.

GENERAL VIEW OF THE ANDES.

This view is taken from Humboldt, on the elevated plains near Quito, which are 3,300 yards above the level of the sea; above which Chimborazo and some other mountains are raised above another 3,000. The cones of burning volcanoes present themselves on every side in this sublime region.

GENERAL VIEW OF THE ALPS.

The tops of the Alps, like those of all high mountains, are continually covered with snow; and immense glaciers or mountains of accumulated ice fill their intervals, sometimes continued, in wonderful masses, from one valley to another, on the declivity of the summits. The view from Berne as exhibited in the engraving is very grand, and is copied from the Berne Guide, and may be regarded as a faithful representation.

At the glaciers of Grindelwald and Bois, in the valley of Chamouni, these sublime horrors may be admired to advantage. From an insulated summit the eye beholds a sea of ice, whence arise crystalline blocks, transparent walls, and prismatic needles, confusedly intertwined, resembling the wrecks of a storm whose fury has abated. The brilliant reflections, the colours of the rainbow, and lights infinitely diversified, enrich this view.

MONT-BLANC.

This sovereign of the Alps is about 15,000 feet above the level of the sea; and, being perpetually covered with snow, and visible a hundred miles round, has acquired its name from its brilliant whiteness. Though surrounded by ridges of other mountains, and connected by Alpine tracks, yet, till within these few years, its ascent was deemed impracticable. M. Saussure has published the best account of the whole district; and we have copied his view of the mode adopted in ascending these dangerous precipices. At length, some adventurous English travellers reached its summit, by conveying with them three days' provisions, and conveniences for night-shelter; but, in a similar attempt made in 1822, some other adventurous travellers perished. Besides the difficulties presented by walls of ice and accumulated snow, unfathomable chasms and frightful precipices frequently arrest the course.

THE MIAGE.

This is one of those mixed mountains of ice and granite which surround Mont Blanc. Nothing can exceed it in peculiarity of objects, in desolation, and terrific grandeur. It affords no support to animals of any kind, and is therefore deserted by all. The masses of ice seem to have been accumulating since the Creation, and their bulk and splendour in the sunshine are indescribably wonderful.

CHAMOUNI.

The village of Chamouni is situated in a little valley, close to the immense glacier of Mont Blanc; and this, as well as other places of human habitation in the same vicinity, are frequently exposed to the destructive effects of slippings or falls of enormous mountains of ice upon them, which too frequently destroy men, cattle, and every thing in their course.

MONTSERRAT.

This Spanish mountain is famous for its serrated and pointed appearance, and in that respect is one of the most remarkable prominences in the world. It is, moreover, a noted focus of monkish superstition; a number of lazy anchorites residing in cells on its most inaccessible pinnacles, where they are fed by the bounty of the credulous.

SNOWDEN.

Although Snowden is only 3,500 feet above the level of the sea, and a mere mole-hill compared with the Himalayas or Andes, yet it serves to afford the inhabitants of England a specimen of mountain scenery, and is to them an imposing natural curiosity.

SAUSSURE ASCENDING THE ALPS.

M. Saussure passed several years among the Alps, exploring their recesses and examining their phenomena. This engraving, copied from his work, illustrates the ingenious means adopted to enable him with safety to ascend its crags and slippery precipices; and the engraving affords an idea of the similar means by which such mountains in general are explored by men.

GIANTS' NEEDLE ON THE ALPS.

This remarkable object consists of nothing more than a granitic or phophyritic projection towering above the snow. The contrast of colours render it conspicuous to a great distance.

THE DEVIL'S BRIDGE.

This view is introduced for the purpose of increasing the representations of the scenery of the Alps. This bridge was thrown over a chasm of an immense depth, which intercepted a road through the mountains; and, its construction being considered almost miraculous, it was ascribed by the vulgar to the devil, and hence its name. It fell a short time since, and has not, we believe, been replaced.

SOURCES OF THE GANGES AND JUMNA.

We have introduced this view from the grand work of Mr. Fraser, for the purpose of showing some of the sublime scenery of the Himalayas. The spot is held sacred by the Hindoos, as the seat of the principal source of the Ganges and Jumna; an object which, for several centuries, was a question of great geographical curiosity.

THE PHILOSOPHY OF MOUNTAINS.

This table assembles a most interesting number of facts relative to the phenomena of mountains, in addition to the other engravings. It leaves nothing more to desire on the subject. It is a study by itself, and merits the special attention of the reader. It is drawn up from materials furnished by M. Humboldt. United with the engraving of mountains, it renders the subject complete.

COPPER MINE IN SWEDEN.

The copper and iron mines of Sweden are the most celebrated and most valuable in Europe, and are of wonderful magnitude.

The exterior of this mine presents a vast chasm of a tremendous depth. The passage into the great chasm is by ranges of wooden steps. Here are to be seen the same caverned portico, the rocky, rough descent, the steaming sulphur, and all deadly stenches. The wretched inmates of this gloomy cavern appear like so many spectres. In one part the steam is so excessively hot as to scorch at the distance of twelve paces, at the same time that the sulphureous smell is intolerable. Near this spot a volcanic fire broke out some years ago, in consequence of which, strong walls were constructed, as barriers to its power, and several contiguous passages, which, had it spread, would have proved dangerous to the mine, were closed up. The depth is twelve hundred feet, and a full hour is required to reach the bottom. The mass of copper lies in the form of an inverted cone.

SILVER MINE IN POLISH PRUSSIA.

This celebrated silver mine is near Koningsberg, and is called in the country "God's Blessing." It yields many hundred pounds of rich ore per week, and is above 1,000 feet in perpendicular depth. At the bottom is an immense space filled with fires, to soften the stone, and with swarms of miners, making the most hideous appearance.

SALT MINES OF CRACOW.

The bowels of the earth, besides yielding metals and various stones, are found, in some situations, to contain strata of solid salt, called Rock-salt. Whether these salt strata have arisen from the drying-up of salt lakes, or whether the saltness of the sea arises from its contact with salt strata, has been made a question. Be this as it may, Cheshire and Poland present rich veins or strata of salt; and in some situations water is impregnated with salt, doubtless from passing through strata which produces a strong brine, from whichsalt is made by evaporation.

The mine at Cracow is very magnificent. It is 800 feet deep, 6000 feet long, and 2000 feet broad, filled with numerous passages, in which reside the miners with their families; many of whom never see the light of day. This salt-mine has, however, ceased to be wonderful for its magnitude, since the mines of Peru, Sweden, Britain, and the Low Countries, have been wrought to so much greater extent.

THE GIANT'S CAUSEWAY IN THE NORTH OF IRELAND.

This wonder of nature consists of a vast collection of basaltic pillars. The principal, or grand causeway, (there being several less considerable and scattered fragments of a similar nature,) consists of an irregular arrangement of many hundred thousand columns, formed of black rock, nearly as hard as marble. They are of unequal height and breadth; and several of the most elevated are of the height of about twenty feet.

This grand arrangement extends nearly two hundred yards, as it is visible at low water; but how far beyond is uncertain, from its declining appearance. The breadth of the principal causeway, which runs out in one continued range of columns, is in general from twenty to thirty feet, and in some parts it may be nearly forty. The figure of these columns is, with few exceptions, pentagonal, or composed of five sides; yet there are not two columns in ten thousand to be found which either have their sides equal among themselves, or display a like figure. The columns, or pillars, are composed of several short lengths, nicely joined, and articulated into each other like a ball and socket, or like the joints in the vertebræ of some of the larger kind of fish. The length of these particular stones, from joint to joint, is various: in general, from eighteen inches to two feet long; and, for the greater part, longer towards the bottom of the columns than nearer the top.

Notwithstanding the general dissimilitude of the columns, relatively to their figure and diameter, they are so arranged and combined at all the points, that a knife can scarcely be introduced between them, either at the sides or angles. At the depth of ten or twelve feet from the summit of the cape of Bengore the rock begins to assume a columnar tendency, and forms a range of massy pillars of basalt, which stand perpendicular, presenting, in the sharp face of the promontory, the appearance of a magnificent gallery or colonnade, upwards of sixty feet in height. This colonnade i ssupported on a solid base of coarse, black, irregular rock, nearly sixty feet thick, abounding in blebs and air-holes; but, though comparatively irregular, it evidently affects a peculiar figure, tending in many places to run into regular forms, resembling the shooting of salts and many other substances during a hasty crystallization. Beneath this great bed of stone stands a second range of pillars, from forty to fifty feet high, more exactly defined, and emulating in the neatness of its columns those of the Giant's Causeway.

GENERAL VIEW OF STAFFA.

It appears by the view that Staffa is an entire basaltic formation, and its vicinity to the Giant's Causeway and to other basaltic islands seems to prove, if basalts are really of volcanic origin, that some great volcano exerted its energies in these seas, in some remote age of the world. Perhaps the Brahminical tradition of the great churning, as they call it, in this northern ocean, may refer to the period in question.

FINGAL'S CAVE, IN STAFFA.

This stupendous cavern is 371 feet long, and about 50 feet high, formed by an eruption of the sea, among a mass of grand basaltic pillars, themselves wonders of the world. It is supported by ranges of columns, and is roofed by the bottoms of such as have broken away. From the interstices of the roof, a yellow stalactic matter has exuded, which defines the different angles. The whole cave is so lighted from without, that the further extremity is plainly distinguishable. The highest range of pillars is to the north-west, and the surface of the stratum by which it is supported is rough, while the base is composed of heterogeneous parts, resembling lava.

FOSSIL REMAINS.

The subjects of Fossil Remains consist of parts of animals, plants, fishes, and shells, which either have been impregnated with silex, and become of stony hardness, with calcareous matter, and petrified, or imbedded in stones of various descriptions; and, in one case, we have given a specimen of marble, composed entirely of the visible remains of shells, a variety of which is so common in many districts, that it is used for ordinary purposes; and also various specimens of fish's teeth. These remains have evidently been entangled, during great changes, which have taken place on the earth's surface, in very remote ages; and they include an infinite variety of genera and species, no longer to be met with.

The five plates contain representations of 135 different species, classed under their respective names of various shells; remains of plants imbedded in stone; fish's teeth; and other organized productions living on the earth before the formation of the present strata.

In one of the larger specimens, various vegetables and their seed are assembled in one stone: the seed resembles coffee; and there is also a branch of Fern, with the vegetable of the verticillate tribe.

The fossil marble is so common in Sussex that the streets of Lewes are paved with it; and it consists entirely of shells united by cement. The fossil animal was published by Cuvier, and found near Paris.

All these objects are too interesting to be slightly passed over by the lover of antiquities or the student of Natural History.

FOSSIL SHELLS, &c.

Independently of the shells at present found in the sea, and occupied by living animals, many varieties resembling these, but often very dissimilar, are found in a fossil state, bedded in rocks, and often forming entire strata of vast extent by themselves.

Pectines. These include the whole of the oyster or scallop classes. The shell is bivalve, generally with unequal valves, and slightly eared. Their form is usually regular, and their surface is adorned with elevated divergent ribs, varying in number from five to forty, which proceed from the tip of the beaks to the extremity of the margins, there terminating in a scalloped outline. The ribs are variously diversified with beautiful colours and delicate checquer-work. The margins of the interior are mostly crenated, and are often beautifully coloured. The scallops have the faculty of leaping out of the water, and are enabled to effect a very rapid motion, by opening and closing their valves. In the plate, ten beautiful varieties of fossils of this order are exhibited.

Coni or Cylindri. The numerous species of the cones are very similar in form. Their colour and markings are extremely beautiful and much diversified: in some species they are elegantly disposed in dots, stripes, bands, and reticulations; and in others, delicately blended in cloudings, veins, and marbling.

The Tubulus Marinus belongs to the tubular family, first pointed out by Langius.

The Concha Margaratifera belongs to the order of bivalves, and is still found in several rivers of Britain. The shell is ovate-oblong, and is covered with a black epidermis. The length is two inches and a half; and the breadth, five inches. It often produces pearls of a considerable size, and of a good colour.

Dentalia. The shells of this genus resemble an elephant's tusk in miniature, and the principal distinctions are in magnitude, curvature, and the number of ribs and grooves. The Dentalia are now principally found in the Indian and European Oceans; and a few in the Mediterranean and Northern Seas.

Ostracites, a beautiful specimen of the genus Ostrea, or Oyster.

Helicites, the Snail or Spiral. This extensive genus consists principally of land or fresh-water shells, a very few only being the produce of the ocean; but in fossil remains they are found in prodigious quantities.

Nautili. The most striking character of this genus is that the whorls are divided into separate compartments or chambers, which are connected by a slender syphon running spirally through the shell. The general form of the shell is spiral or scrawl like. Fine specimens of the Pompilius genus are often converted by the inhabitants of the East into drinking-cups, on the surface of which they engrave various devices and ornaments. Some species of the Nautilus are found adhering to coral rocks on the Sicilian shores. The American and Indian Oceans, as well as the Mediterranean, Adriatic, and Red Seas, produce species of Nautili; but the greater number are found on the European and British coasts.

Buccina or Whelks. This genus derives its name from some of its species, resembling a trumpet *(buccinum.)* The African, American, Indian, European, and Southern Oceans, produce the greater number of buccina, and many are found in the British and Mediterranean Seas.

Trochi. The leading characteristic of the Trochus, or Top Shell, is the conical shape of its species. A few species have their surfaces almost smooth; but the greater number are covered with knobs, spines, or undulations. Many, when uncoated, present a brilliant mother-of-pearl appearance; others have only a pearly appearance, and a few exhibit a bronze-like hue. The Trochus derives its name from the resemblance of its species to the form of a top, and is found in almost every part of the world.

Neritæ, or Hoof Shells. There is a considerable variation in the form and markings of these shells. This genus received its name from its species having been supposed by ancient naturalists to have the power of swimming in the ocean.

Orthoceralite, is a genus of the Nummulite family, so abundant as to fill whole tracts of country, and so ancient that they abound in the lime-stone of which the pyramids of Egypt are built. They are of the shell kind.

Gryphites, are a species of bivalve shells, often found petrified in lime-stone.

Ammonites, are another tribe of fossil shells, of which no less than 300 different species have been described. They are vulgarly called snake-stones, from a notion that they were petrified serpents. They are found in vast abundance.

Asteriæ, or Star-stones, are fossil or petrified remains of the Star-fish, but are rarely met with.

The subjects of plants found in stones speak for themselves, and are met with in great abundance; some of them like existing vegetables, but found in countries where they no longer flourish.

Madrepores, Tubipores, Corals, and other productions of polypi, are frequently found in a fossil state, and are known under the names of *porites* and *corralium*; and even sponges are often found in a fossil state in flint and chalk.

Entrochites, are fossil remains of the Radiaria, a family now scarce, but which appears to have been very abundant when the existing animals were converted into fossils.

Fossil Teeth, or Glosopetræ; so called from a vulgar notion that they were the tongues of serpents; whereas, in truth, they are the teeth of sharks and other fish.

Buffonitæ, another class of fishes' teeth, but which were once imagined to be parts of the heads of toads.

Ichthyperia, consist of fossil remains of fishes, and are often found in the earth in a mineralized state.

SKELETONS OF THE FOSSIL SLOTH AND MAMMOTH.

Among other remains of quadrupeds, where continuance has become unfit or discordant with the state of the world, in other respects, are some varieties of enormous animals, whose remains are constantly found in exploring the strata of all countries.

One of these is the *American Mammoth*, whose bones are still exposed in great quantities on the banks of the Ohio, and a perfect specimen of which creature is to be seen in the Museum at Philadelphia. Its relative size to a man of middle stature is displayed in the engraving. When these animals became extinct is unknown; but the Indians have traditions that they were formerly so formidable as to drive men into caverns for safety.

The other specimen is of another genus, in which bulk is happily counteracted by awkwardness of structure. This creature is of the sloth kind, of the species called *Megatherium*, and its relative size to that of man is indicated by the figure. It was found in South America, and is now preserved in the museum at Madrid. Bones of animals, equally enormous, have been found in all parts of Britain; and the common existence of such creatures gives rise to interesting speculations relative to the state of the world when they flourished. The existence of enormous animals appears constantly to become more and more unfit. Thus, the rhinoceros, the elephant, the hippopotamus, the camel-leopard, &c. &c. are constantly becoming scarce, and wholly extinct, in countries where they formerly existed in great numbers.

The remains of this enormous awkwardly-constructed animal were a few years since found in Paraguay; and, being conveyed to Spain, were deposited in the Museum of Madrid. The difficulty with which a creature whose motions must have been so awkward could have found adequate subsistence must have led to the speedy extinction of the species, in spite of the prolific character of the country in which these remains were found. It is impossible to view these gigantic remains of creatures whose race is now extinct without feelings of mingled delight and astonishment.

MAMMOTH IN THE MUSEUM, PHILADELPHIA.

The bones of this animal abound in the vicinity of salt-springs near the Ohio, and are found also in other parts of North and South America. Its enormous dimensions are proved by M. Montulé's drawing, where he is represented reaching to touch the ribs. Its tusks distinguish it from those of the Siberian mammoth, which turn upward, and from the mammoth found in the Rio de la Plata, which was without horns; but the entire genus are of similar magnitude, i.e. twelve or fifteen feet high, and 20 or 30 long, their bones being massive in proportion to their bulk. The Indians have a tradition that they once were the terror of the woods, and that men were obliged to retreat to caves to escape from their ravages.

GROTTO OF ANTIPAROS.

Till the discovery of the great Cavern of Kentucky, this grotto was for ages regarded as the greatest natural curiosity of its kind. It consists of a series of chambers, whose roofs are covered with beautiful and transparent stalactites, or oozings from the superior ground of the very substance which, when strata are beneath, forms the solid cement of those strata, and converts loose matter into the hardest solids. The figured forms on the ground are composed of beautiful crystals, and icicles of white marble. The cavern is usually visited by strangers with torches, the reflection of the light of which, from the stalactites, produces an enchanting effect.

Derbyshire abounds in similar caverns, but the above is the finest specimen which could be given.

DEVIL'S PEAK, AND GRAND CAVERN, DERBYSHIRE.

The Peak of Derbyshire is famous for its subterranean, geological, and mineralogical wonders. Among these, the Peak Cavern, near Castleton, is very famous for its size and extent: it is 2250 feet in length, 620 feet below the surface, and in some parts 300 feet high. The Grand Cavern is a recent discovery; and doubtless others will be found on further examination, as the whole district is irregular, and full of cavities.

PLAN OF THE GREAT CAVE IN KENTUCKY.

Of other Caverns we have been able to give particular views, but this extensive and unparalleled range of galleries, of halls, and immense domes, would, if represented, furnish a picturesque work by itself. The figure at the side represents a human subject, probably the remains of some unfortunate Indian, who was bewildered in the Cavern.

A—Mouth of the cave, 40 feet high, and 30 wide.

BB—Hoppers, where saltpetre is made by the owners of the cave. Oxen are worked two miles in.

C—Pits, 175 feet deep in many places in this chamber.

D—This area contains upwards of eight acres, covered with one arch, at least 150 feet high in the centre. It is called the *Chief City*.

E—*Second City*, contains about six acres; the walls around at least sixty feet perpendicular height: one arch.

F—*Fourth City*.

G—This is called the *Fifth City*.

H—The bed of this chamber, which is 1800 feet in circumference, is forty feet above the level of the passage leading to it. You go up a passage like a chimney forty feet perpendicular.

I—At this place a cedar pole was found, twelve feet long, and perfectly sound.

O—No farther explored.

L—*Third City*. From the side of the cave issued a fine stream of water, which falls sixty feet.

R R R—Green River passes over three branches of this cave.

S—A long body of yellow ochre found here.

T—A very beautiful dome, at least forty feet diameter and sixty feet high.

X—Here are six or eight large columns of spar, standing upwards of sixty feet perpendicular height, the bases of which rest in elegant basins of water, as clear as amber. Soda is found in great quantities in and near these columns of spar.

Z—Found no end.

N—Ditto. Ditto.

THE GROTTO DEL CANE.

This is an inconsiderable cavern between Naples and Puzzuoli, situated in a volcanic district. It contains a small lake, over which hangs an atmosphere of carbonic acid gas, commonly called fixed air. If, then, a dog be plunged into this gas, he immediately loses all signs of life; but, on being drawn out, he speedily recovers again.

This was an object of great wonder among travellers and superstitious persons, till the density and deleterious character of carbonic acid gas were ascertained.

NATURE DISPLAYED.

PART II.

LECTURE XX.

ON THE SOLID PARTS OF THE EARTH.

Then range through being's wide extent
Let the fair scale, with just ascent,
    And equal steps be trod;
Till, from the dead corporeal mass,
Through each progressive rank you pass,
    To Instinct,—Reason,—God!

BEINGS five or six feet high, are poorly qualified to judge of the comparatively vast globe on which they live, by viewing it from their own puny elevation, or indeed from any elevation which they are able to attain. To conceive of it correctly, they should view the distant heavenly bodies, as the Moon, which is even sixty-four times smaller, or Jupiter, which is a thousand times larger. The contemplation of such distant bodies will correct all their notions, and harmonize all their sentiments relative to the bulk of the earth.

They are apt to be surprised, when they traverse mountains so vast compared with themselves, and to ascribe great energy to the means which transport such vast masses through space, and revolve them round the axis of the earth. But if they carry their reasonings to Jupiter, either as seen with the naked eye, or through a telescope, these difficulties vanish, though every part of Jupiter is one thousand times greater than an equal fraction of the earth. In truth, all the movements of nature balance one another, and no violence is necessary; for if any inequality arise, it is instantly corrected by the combination of other forces. Every person is sensible of the little force which is necessary to turn a large horizontal wheel; although such wheels are subject to the friction of the axle on which they rest; for example, an horizontal wheel, of thirty or forty feet diameter, which could not be lifted by twenty men, can, nevertheless, be turned with great velocity by the hand of a child, and the velocity can be kept up by the gentlest exertion only of the little finger: for each side exactly balancing the other, counteracts the weight of the whole. Just so it is with the earth; the sides of the whole sphere, all round the axis, balance the opposite side, and while the balance of the sides continues, an exceedingly slight force is sufficient to turn even such a vast body, and produce the wonderful phenomena of day and night*.

A question, however, presents itself to every curious mind, in regard to the internal or component materials of so vast a mass; whether it be entirely solid, whether it is more dense at the centre than the surface, and many such questions, which have long agitated the curious creatures who have never been able to penetrate a single mile into it; and who, from the difficulties, at once gaseous, fluid, and solid, may never be able to penetrate to a greater depth.

The impossibility of gratifying curiosity on this subject has led to a number of absurd hypotheses; some, for example, have maintained that the earth is hollow; and that we live only upon the shell, as though such were the construction of all the planetary bodies. Others, believing this, have filled the hollow with fire, ignorant that fire is a mere gaseous action, and cannot exist without oxygen and hydrogen;—while some of this class fill the hollow with water, ignorant that the rotation of the earth and the re-action of the moon necessarily bring all the water to the surface. Others, again, have pretended to determine the exact density of the whole earth, by imagining that they had found the relative attraction of a mountain of known density; though it is palpable, that the plummet which they used was carried towards the mountain by the pressure of the external column of air†, and therefore, that no attraction (if such a chimerical power could be supposed to exist) could be concerned. All these hypotheses are therefore

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* See page 121.

† Just as two cork bungs, floating above water, are carried together by a similar pressure of the external columns of air; although, if of oak, and floating within the same water, they would make no approach.

so many vagaries of the human mind, unworthy of sober attention.

But astronomers are enabled, by knowing the bulks, distances, and periods of the several planets, to determine their *relative* density; though the real density, with reference to any particular substance on the earth, will probably remain for ever unknown.

The law of planetary aggregation, as established by Sir Richard Phillips (to whom we are indebted for the preceding observations), proves that the circle of rotation of every part of the earth is necessarily inversely as its density. Thus, at the equator, atmospheric air is carried round at the surface, or twenty-five thousand miles in twenty-four hours, with little inclination to move lower, and the *common* force (like that of a hand turning a horizontal wheel), which carries round the whole earth, is not competent to carry an equal bulk of lead through the same circuit; consequently, if a bulk of lead were in the same situation as an equal bulk of the atmosphere, the common force would not carry it, and it would be precipitated to such a distance from the centre, as accorded with the difference between its weight and that of an equal bulk of atmosphere having no weight. Hence, the momenta of bodies of different densities, while revolved by a common force, is equal, or seeks to become so, it being at the same time remembered, that the whole earth is moving in its orbit with a velocity *sixty times* greater.

We are hence to conclude, that as all bodies which are heavier than air (of a density somewhat lighter than that of the surface) are forced to adjust themselves nearer the centre than we find them, so all the parts of the earth have a continued disposition to consolidate, and would therefore exhibit effects constantly ruinous to the inhabitants of the surface, were not the whole built up (so to speak) from the centre to the surface, of solid masses, which, for any thing we know to the contrary, may consist of those primitive rocks which peep through the heterogeneous and compounded surface in Himalayas, Andes, Alps, Pyrenees, &c. We shall proceed, therefore, to exhibit what is known of these, and then treat of those classes of rocks and earthy compositions, which in the progress of time have, by their own actions and re-actions, and by the operations of air and water, produced what in the popular sense is called the surface of our planet.

Primitive Rocks.

Primitive Rocks lie under the rocks of the upper surface, but, owing to the inequalities of their original forms, frequently rise through them, often very high, as mountains and mountain chains. Countries composed of primitive rocks are more rugged and lofty, their cliffs more extensive, valleys narrower, deeper, and more uneven, than those in secondary mountains. The strata, frequently highly inclined, contribute to increase the ruggedness and inequalities of the surface. The primitive strata in many countries maintain a remarkably uniform direction; in Scotland, this generally is from N. E. to S. W.; and the same nearly in the vast alpine regions of Norway, and in many other of the lofty primitive lands in Europe. In Scotland, the direction is so invariable, in both the primitive and transition strata, as to serve travellers in place of a compass, through the mountain wilds of the Highland regions. The rocks which compose primitive mountains and plains, are of a crystalline nature, and present characters of their formation from a state of solution: these characters are—the intermixture of the component concretions at their line of junction; their mutual penetration, considerable lustre, pure colours, and great translucency. Thus, in granite, the concretions of felspar, quartz, and mica, are joined without any basis; and at their line of junction, are either merely closely attached, or intermixed; and, often branches of the one concretion shoot into the other, occasioning a mutual interlacement, as observed in bodies formed simultaneously, and from a state of solution. These characters show that the concretions of granite (and the same applies to the concretions in limestone, gneiss, mica-slate, and other rocks of the primitive class) are crystalline, and have been formed at the same time.

The strata are so arranged in mountains, one set including another, as to render it probable, that their seams are not a mechanical effect, but produced the same as the seams of distinct concretions, or the surfaces of crystals. These strata, collected in groups, cause *formations*, as gneiss or mica-slate; and, where the rock is not distinctly stratified, it exhibits such characters as point it out in a formation in the grand series, which forms the crust of the earth. The rock formations in primitive countries, though well marked and distinguished by general and particular characters, are not isolated, or unrelated; but, as they approach and join, we find gradual transitions of the one into the other, or intermixtures and interlacings at their great lines of junction. No true primitive rock appears foreign to the others, or exhibits characters intimating a different mode of formation. Thus granite (by some considered a kind of lava, and therefore formed different from gneiss or mica-slate) passes into and is intermixed with the surrounding rocks, and therefore has been similarly formed.

Primitive rocks are distinguished from the other classes, by the absence of all fossil organic remains. Whence the inference, that organic beings had not been called into existence during the formation of primitive rocks; and that there was a time, in the history of the formation of our planet, when plants and animals did not exist. Though traces of organic life do not occur in primitive rocks, yet they afford beds of a kind of coal (glance coal), composed almost entirely of carbon, a substance often considered as peculiar to the organic kingdom, and when found in the mineral kingdom, supposed to be traceable to previously existing organic beings. This opinion is disproved, by these facts, and the occurrence of carbon in hornblende, slate, and other primitive minerals. Here then is the formation of carbon, independent of animal and vegetable agency.

Limestone has been considered as entirely the result of animal action; and the various formations, whether in primitive or secondary mountains, are viewed as accumulations of altered shells or corals. But as neither occur in primitive mountains, which often contain extensive beds of limestone; and as lime is a constituent of most simple minerals composing primitive rocks; therefore, lime, like carbon, is an original substance in primitive mountains, and has been formed at times independent of animals.

The two most abundant alkalies, viz. sodium and potash, occur in primitive mountains, but of these, potash is most frequent and abundant. Before Klaproth's discovery of potash in lepidolite, a primitive mineral, this alkali was considered as entirely a vegetable production, but no vegetable remains occur in primitive rocks; therefore, the potash has been formed by some other agency.

Phosphate of lime, an important constituent of the higher animals, was long maintained to be exclusively an animal production; its discovery in some vegetables, demonstrated its occasional production in some tribes of plants; and then it was believed to be either of animal or vegetable origin. But geologists, by discovering apatite, or phosphate of lime, in primitive mountains, prove its existence in nature, independent of organic agency.

Primitive rocks abound in metalliferous minerals, and hitherto no metal has been found, not occurring exclusively, or occasionally, in this class of rocks. Tin, wolfran, and molybdena, occur oftener in these rocks than in others. Gold, silver, lead, copper, iron, cobalt, zinc, manganese, arsenic, and mercury, occur either disseminated, in beds and veins, or imbedded, in various primitive rocks; and many primitive districts are characterized by their metalliferous repositories; as Strontian, by its particular venigenous formation of galena, or lead-glance; Königsberg, in Norway, by its group of veins of silver-ore; and the primitive gneiss rocks of Arendal and Lapland, by their beds of magnetic iron-ore.

The most beautiful mineral productions, the gems, occur in great variety in primitive rocks. Nothing can be more beautiful than the cavities in primitive mountains, whose walls are lined with pure and variously coloured and crystallized topaz, beryl, and rock crystal; the gneiss, granite, and mica-slate, with their imbedded grains and crystals of sapphire, chrysoberyl, and garnet; and the veins in granite, clay-slate, and other primitive rocks, with their emeralds, axinite, and spiral ruby.

But the most precious of all, the diamond, is wanting in primitive regions. Judging from its splendid lustre, pure and beautiful colours, high translucency, and great hardness, it might be expected to occur in the cavities or veins of primitive rocks; but, it appears only in alluvial deposits of gravel, clay, and sand, of new formation, immensely removed from those that form the grand basis of the earth's crust, thus intimating its recent origin.

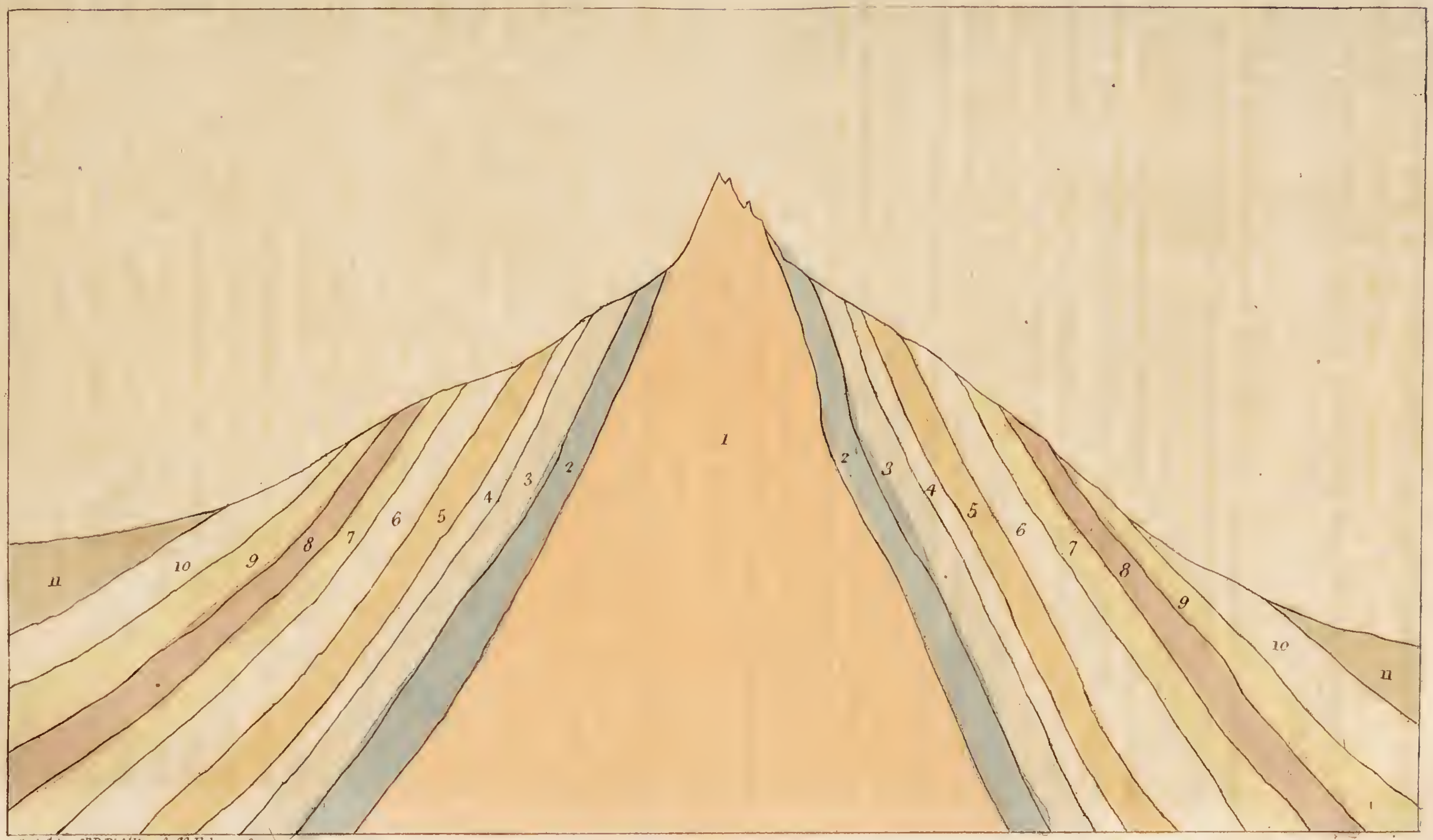
Hence the knowledge of these rocks is highly interesting, in an economical point of view. The richest and most important mines, are situated in primitive rocks; statuary marble, and the various granites, porphyries, and serpentines, so valued in the arts, and the gems, so distinguished by their beauty of lustre, colour, and great hardness, are principally contained in the primitive formations.

Different Primitive Rocks.

The following rocks occur in primitive mountains; granite, porphyry, trap, serpentine, limestone, gneiss, mica-slate, clay-slate, and quartz rock.

These rocks are very simple, being composed of five minerals,—(described in their proper place among *Stones*)—quartz, felspar, mica, hornblende, and limestone; some rocks are composed of one simple mineral, as quartz rock; others of two, as mica-slate, a compound of mica and quartz; and others, as granite, of three, quartz, felspar, and mica.

1. *Granite;* a granular compound of felspar, quartz, and mica; *syenite* is a variety, with the addition of hornblende. This is the most imposing mass of aggregated substances, and appears in nature in immense vertical blocks, heaped up into a homogeneous vehicle. In its rough state, it has a greyish aspect, with nothing remarkable; but when fashioned, there appear brilliant points with metallic reflections, and strong glaring colours from a dark ground, where the luminous rays either lose themselves, or are reflected in fasciculi. Its close grain, the strong adherence of its atoms, its unctuous lustre, and capability of fine polish, render it



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Section of the Brocken Mountain Hartz Forest Germany.

No. 1. Granite; No. 2 Clayslate; No. 3. Transition or secondary Limestone No. 4. Greywacke & Greywack Slate; No. 5 Old Red Sandstone; No. 6. 1st Flœtz Limestone No. 7. 1st Flœtz Gypsum; No. 8. 2d or variegated Sandstone; No. 9. 2d Flœtz Gypsum; No. 10. 2d Flœtz Limestone. No. 11 Alluvium deposite.

useful to perpetuate the power of individuals, and the civilization of nations.

Mont Blanc being the most remarkable granitic mountain on the globe, a short account of it may be appropriate.

Its height is about 15,562 feet; and, considered as an integral elevation, independent of measurement from the level of the sea, it is probably the highest on the globe. The base of Chimboraço is more than 10,000 feet above the level of the sea, which gives the mountain its superior elevation, while its mass is, in fact, considerably less elevated.

It is encompassed by those wonderful collections of snow and ice, called "GLACIERS." The highest part, named the Dromedary, has the shape of a compressed hemisphere; it sinks gradually, and presents a concave surface of snow, with a small pyramid of ice in the midst. It then rises into a second hemisphere,—the Middle Dome; and thence descends into another concave surface, terminating in a point, regarded as the inferior dome, among other names, by the Savoyards, styled "Dôme de Gouté."

The first successful attempt to reach the summit was in August, 1786. Doctor Paccard, a physician of Chamouni, was led to make the attempt, by a guide, named Balma, in searching for crystals, discovering the only practicable route for accomplishing so arduous an undertaking. The ascent occupied fifteen hours, and the descent five, under circumstances of great difficulty; the Doctor and his guide, Balma, being almost blinded by the snow and wind; their faces were excoriated, and their lips exceedingly swelled*.

On the first of August, 1787, the celebrated and indefatigable naturalist, Saussure, set out on his successful expedition, accompanied by a servant and eighteen guides, who carried a tent, mattresses, and the necessary accommodations, and various instruments of experimental philosophy. The first night they passed under the tent, on the summit of the mountain of La

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* Two English gentlemen, whom I have the pleasure of knowing, were on the spot at this period, and they affirm, that the guide had been on the summit of the mountain before he conducted Paccard or Saussure thither. EDITOR.

Côte, 4986 feet above "the Priory," a large village in the vale of Chamouni; the journey thither being exempt from trouble or danger, the ascent being always over turf, or on the solid rock; but above this place wholly over ice or snows.

Early next morning, to gain the foot of a small chain of rocks, enclosed in the snows of Mont Blanc, they traversed the glacier of La Côte, which is both difficult and dangerous; intersected by wide, deep, irregular chasms, frequently passable only by three bridges of snow over the abyss. After reaching the chain, the tract winds along a valley, filled with snow, extending, north and south, to the foot of the highest summit, and divided at intervals by enormous crevices. These shew the snow disposed in horizontal beds, each answering to a year; and, notwithstanding the width of the fissures, the depth can in no part be measured. At four in the afternoon, the party reached the second of the three great platforms of snow they had to traverse, and here they encamped at the height of 9312 feet above the Priory, or 12,768 feet, (nearly two miles and a half,) above the level of the sea.

From the centre of this platform, enclosed between the farthest summit of Mont Blanc, south, its high steps, or terraces, east, and the Dôme de Gouté, west, is seen only snow; quite pure, of a dazzling whiteness, and presenting a singular contrast with the sky, which, in these elevated regions, is almost black. Here is no living being; no appearance of vegetation; it is the abode of cold and silence. "When," says M. de Saussure, "I represent to myself Dr. Paccard and James Balma, first arriving, on the decline of day, in these deserts, without shelter, assistance, or even the certainty that men could live in the places they proposed to reach, yet pursuing their career with unshaken intrepidity, it seems impossible to admire too much their courage and magnanimity."

The company departed, at seven the next morning, to traverse the third and last platform, whose slope is extremely steep, being in some places thirty-nine degrees. It terminates in precipices on all sides; and the surface of the snow was so hard, that the foremost were obliged to cut places for the feet with hatchets.

The last slope presents no danger; but the air is so highly rarefied, that the strength is speedily exhausted; and, on approaching the summit, it was necessary to stop at every fifteen or sixteen paces to take breath. At eleven they reached the top of the mountain, where they continued four hours and a half, during which time M. de Saussure enjoyed, with rapture and astonishment, a view the most extensive, as well as the most rugged and sublime, in nature, and made those observations which have rendered this expedition important to philosophy.

The naked rocks there met with, and which form *arrets* or crests, of a black colour, are granites, here detached in scattered fragments, there, in solid rocks, divided by fissures nearly vertical. The felspar which enters into the composition of these rocks is white, approaching to grey, or green, or reddish, here pure, there covered or even mixed with a substance of a grey or greenish colour. The whitish, semi-transparent quartz, which enters into the composition of this granite, appears a little unctuous in its fracture; and is more fusible than rock crystal. These granites are often mixed with hornblende, here whitish, there inclining to green. Chlorite also is seen, often of a blackish green, in veins, nests, and even in masses. It is soft, but not friable, and a very fine grain; and its small particles, viewed by the microscope, seem to be very translucent thin plates, of a bright green.

Some of these granites appear curious; having small irregular and angular cavities, full of a brown dust. In breaking these granites, in their interior are small pyrites, brown and dull on the outside, but brilliant, and of a pale yellow within, affecting the magnet. Also there is quartz, with veins and nests of actinote, in rather confused crystals. In some parts, the granite degenerates into irregular schistous rocks, of quartz and felspar, without mica; the layers separated and covered with an argillaceous earth. Primitive petrosilex, of a greenish grey colour, was also found among them.

A light vapour, suspended in the lower regions of the air, concealed from the sight the lowest and most remote objects, such as the plains of France and Lombardy; but the whole surrounding assemblage of high summits, appeared with the greatest distinctness.

M. de Saussure descended with his party, and the next morning reached Chamouni, without the smallest accident. As they had taken the precaution to wear crape veils, their faces were not excoriated, nor their sight debilitated. The cold was not found so extremely piercing as described by Dr. Paccard. By experiments with the hygrometer, on the summit, the air was found to contain only a sixth portion of the humidity of that of Geneva; to which dryness, M. de

Saussure imputes the burning thirst he and his companions experienced. The balls of the electrometer diverged three lines only, and the electricity was positive. It required half an hour to make water boil, while at Geneva, fifteen or sixteen minutes sufficed, and twelve or thirteen at the sea side. Not any of the party discovered the smallest difference in the taste or smell of bread, wine, meat, fruits, or liquors; (as some travellers have pretended is the case at great heights;) but sounds were much weakened, from the want of objects of reflection. Of all the organs, that of respiration was the most affected, the pulse of one of the guides beating ninety-eight times in a minute, that of the servant one hundred and twelve, and that of M. de Saussure one hundred and one; while at Chamouni, the pulsations respectively were forty-nine, sixty, and seventy-two. A few days afterwards, Mr. Beaufoy, an English gentleman, succeeded in a similar attempt, although it was attended with greater difficulty, arising from enlargements in the chasms in the ice.

2. *Porphyry,* equally prized with granite, composed of a basis containing crystals of felspar of different colours and sizes, and sometimes of quartz and hornblende; however, only imbedded one in the other, instead of being, as in granite, so dissolved as to crystallize confusedly. It was long supposed, that the base or ground of porphyry, was jasper; but it is ascertained to be trap. In this is found hornblende, or *cornéene,* colouring the compound; and a seeming mixture of silica and magnesia;—thus, in porphyry, the components have not reached the term of crystallization, except the felspar. After the red, grey, and black porphyry, most esteemed, come the *ophite* or green serpentine, of which, ancient monuments present several varieties.

Porphyroid is a porphyry with petrosiliceous or magnesian paste; while the porphyrites, besides their crystals not being of felspar, present in their elements a confused mixture, preventing the distinction of the paste from the crystals. All these rocks mostly meet in granite; but granite is also sometimes incased in porphyry, in general less abundant.

The magnesian rocks are of the same formation; their elements, destined to the same end, have not attained it from accidental causes, and have formed distinct masses, in a manner sunk in the larger masses of granite which surround them, and which they sometimes penetrate. These are *trap, serpentine, amygdalyte.*

3. *Trap.* This name is given, because these rocks, on exposure to the air, assume the form of steps. They are composed of *grunstein,* greenstone, and hornblende; the former by addition of felspar to the latter.

4. *Serpentine,* is dark green rock. The *amygdalyte,*

(or *maudelstein* of Werner), is a glandulous rock, composed of trap and jasper, with glands, which, being sometimes empty, gives these rocks the aspect of lava. The paste and kernels vary in their nature; sometimes the paste is grey grunstein, seeded with points of calcareous spar; or this with a brown grunstein; as the *variolite of the dræ,* and *toadstone;* or petrosilex with light brown kernels; or greenish ophite with white kernels; as in the *variolites of the Loire* and *Darance.* All the amygdalytes are of the same formation as the granites, in which they are confusedly mixed, and from which the small stones often met with, have been detached by the waters, which carry them away into the beds of rivers.

5. *Limestone.* This rock has generally a greyish colour, is composed of shining granular concretions, more or less translucent. In this formation, there necessarily were superabundant principles, which remained untouched among those destined to concur in it. Such are the calcareous called primitive, in which we recognise signs of a confused crystallization, even in their smallest parts. These calcareous principles, which are statuary marble, are in large blocks, very much raised, and irregular; sometimes incased in other rocks, and sometimes forming external bands. Their distinctive character is, never to offer the least vestige of shells or other fossils.

6. *Gneiss,* differs from granite only by a greater proportion of mica, which renders it more alterable, and of a less close texture, being a granular slaty compound of felspar, mica, and quartz. One of the most interesting kinds is that with red felspar, sometimes of a wavy or undulated structure.

7, 8, 9. *Mica slate, clay slate,* and *quartz rock,* are described in their places among *stones.*

The circumstances already stated, warrant the supposition, that the formation of the mountains was effected by rising, and not by crystallization. When it began, there was no mass of water on the globe; the elements only lately in contact, were not yet completely modified; the actions had more intensity, and were exerted in all their plenitude. The fluids penetrated the mass of the globe to a certain depth, and the atoms detached from it were dissolved in the void; they lost their primitive character, and passed from a metallic to an earthy state; a sort of oxydation analogous to what takes place now. Soon re-action succeeded; the atoms which came off last were the least altered; the expansive force grew weaker by exertion; re-action prevailed in its turn; and the oxydized atoms tending towards the centre, collected round the nucleus by compressing the fluids which held them in solution.

From that moment the *atmosphere* existed, and retained a small part of the atoms, which having been the first dissolved, could not approximate sufficiently to partake in the precipitation of the others. Yet the earth moved according to the laws which carry it now in its annual orbit. The centripetal force of the fluids from the circumference to the centre, developed itself with the rotatory motion. Compressed by the precipitated atoms which they had formerly dissolved, the fluids endeavoured to disengage themselves; and thereby raised all that part of the globe primitively altered or oxydated, so that the highest elevations rose on the equatorial line, while the polar regions exhibited only swells and rugosities.

The earth then had the aspect of an arid surface, horribly cut up, surmounted by enormous mountains, and rugged with deep and extended precipices, such as appear, through the telescope, on the moon and some planets. The ocean was not yet formed; the aqueous vapours did not float in the atmosphere; no river flowed on the earth's surface. But scarcely was the granitic crust raised, when a part of the compressed fluids escaped from the bosom of the earth; frictions succeeded; fire appeared; the gases allowed their imponderable fluids to exhale; their bases combined, water was formed, and occupied the cavities of the globe. The mountains thus most raised between the tropics, there also were formed the greatest depths of the ocean.

The globe was then divided into three great masses;—the Atmosphere, Ocean, and Earth; but the latter was a mere sketch, that was to have successive developments, by the exchanges commenced. The volumes of the atmosphere and ocean, were then more

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CURVED GNEISS IN LEWIS.

considerable, because their mixture with the earth was just begun, and the quantity of air or water they were to furnish to the subsequent compounds, had not yet been drawn from them. Consequently the ocean attained a higher level; with more extended motions, violent agitations, and intense dissolving power. To the granitic formation, its basin was attacked; the vitreous parts were reduced to sand; the calcareous and magnesian parts were melted and kneaded; metallic atoms, detached from their ores, mixed with them; and the whole formed that incoherent assemblage, by Werner named Transition Rocks.

Transition Rocks.

Transition rocks succeed to the primitive; and generally, in this country, occupy a higher level than the secondary, but a lower one than the primitive formations. Their mountains, mountain-ranges, mountain-groups, and cliffs, are more rugged than those of the secondary, but less so, and of softer outlines, than the primitive rocks. Their valleys are wider, and their sides less rugged and abrupt, than those of primitive mountain-groups.

Most of the rocks are distinctly stratified, the strata frequently vertical; and, like the primitive, exhibit the same general direction through great tracks of country. Thus, the strata in the great high land, which ranges from St. Abb's Head to the Irish Sea, almost entirely transition rocks, range everywhere nearly from N. E. to S. W.

Though most transition rocks appear formed from a state of solution, and therefore possess the crystalline character, yet their crystallization appears to be less perfect than in the primitive rocks, because the component parts have less lustre, inferior hardness, translucency, and colours of less purity, than primitive rocks; in short, these rocks have more of earthy aspect, and of fragment character, intimating lower crystallization, than the primitive. But these rocks are further distinguished from the primitive, by the very important circumstance of containing fossil organic remains, petrifactions of corals and shells, animal productions, low in the zoological scale; vegetable remains, of the most simple construction, as cryptogamia, and therefore, at the bottom of the botanical scale. Hence it follows, that the more simple animals and vegetables were first called into existence, and that their creation did not take place until the period of the formation of transition rocks. Coals similar to those in the preceding class, also occur in transition rocks; and numerous extensive beds of limestone (sometimes containing organic remains) in some districts often occur. Transition rocks frequently abound in various ores, generally disposed in veins. The mining districts of the Leadhills and Wanlock-head, near Edinburgh, so rich in galena, or lead-glance, are in transition rocks. The rich lead and silver mines in the Hartz, and many of those in Mexico, are in similar rocks.

The gems which appear in so many interesting forms and relations, in the strata and veins of primitive mountains, are rare in the transition.

The abundant occurrence of ores in this class of rocks; their extensive deposits of limestone, particularly of the variegated kinds, so highly prized for ornamental purposes; their fine granites and porphyries, are sufficient proofs of their importance in the arts.

The following rocks belong to this class; greywacke, clay-slate, limestone, trap, granite, syenite, porphyry, serpentine, gneiss, mica-slate, and quartz-rock.

1. *Greywacke* is a conglomerated looking rock, with a basis of clay-slate, including angular and various shaped portions (by many considered as fragments) of clay-slate, flinty-slate, quartz, felspar, &c. and occasionally, scales of mica. When the imbedded masses become small, and the mass slaty, it is named *greywacke-slate.*

2. *Clay-slate.*—This rock is of the same general nature with primitive clay-slate, but differs from it in having less lustre, and in sometimes containing fossil plants and fossil shells.

3. *Limestone.*—It is more compact, and much smaller granular, and therefore has less lustre, and lower translucency, than the primitive limestone. It is frequently traversed by veins of calcareous spar, and often exhibits,

in the same bed, various tints and shades of beautiful colours. Some varieties are conglomerated, forming the *brecciated marble* of artists, and others contain fossil shells and corals.

The Egyptian *breccia* contains large pebbles of jasper, granite, and porphyry. That from Dunstafnaye, in Scotland, where it forms romantic rocks, of peculiarly abrupt aspect, consists of white quartz, green or black trap, porphyry and basaltin. The celebrated *pudding stone,* found only in Hertfordshire, appears rather an original rock; because the pebbles do not seem to have been rolled by water, which would have worn off the substances, in various directions; whereas the coloured circlets are always entire, and parallel with the surface, like those of agates. If not the first, it ranks very high, in beauty, among rocks; consisting of crystals of various colours, in a siliceous cement, brown, black, dark blue, the more beautiful yellow, and red, and the rarest, green: sometimes approaching to transparent quartz, at others, itself a breccia, of very minute fragments or crystals.

4. *Trap.*—This rock, like that of the primitive class, is principally composed of hornblende, and is sometimes associated with felspar, forming *transition greenstone.*

5. *Granite, Syenite and Porphyry.*—These have the same composition as in the primitive class; and, independent of the characters derived from their mass, and their particular imbedded minerals and veins, are distinguished by the greywacke, with which they are associated.

6. *Gneiss and Mica Slate.*—These rocks occasionally occur associated with the greywacke, and other members of this class.

7. *Serpentine and Quartz Rock.*—These very nearly resemble those of the primitive class; but are distinguished from them, by their connexion with greywacke, &c.

This formation, on depositing, forced the ocean to descend to a lower level, where one portion of the waters combined with these new matters; or another, kept stagnant, between the interstices, and formed lakes; or a third, penetrated the fissures into the interior cavities, which existed since the rise of the granite. This transition land, fixed on the granite, was composed of agglutinated sands, forming species of freestone, or greywacke, compact calcareous masses, magnesian matters or transition trap, and some metallic veins; as those in Derbyshire, in the toadstone and calcareous rocks; those of the Hartz, in the greywacke, &c. &c.

Oxygen had two destinations. One, to oxidate the metallic nucleus, which produced the primitive rocks, and the divers metals distributed in veins, beds, or heaps therein; the other, to form water, which followed on the rise of the granitic envelope, and was occasioned by the disengagement of fluids, &c. A part of this oxygen, absorbed by the inflammable bodies, also formed the acids, and especially the carbonic acid, combined in the primitive limestone. In proportion as changes were effected between the atmosphere, ocean, and earth, their divers component substances more intimately mixed, became severally more divided; and the actions multiplying, augmented the species of compounds. The heat consequent on this atomic motion, then developed the divers properties of bodies; the alkalies and acids reciprocally acted, and the salts were formed; the vapours from the ocean floated in the atmosphere, were impelled by the winds, and broke against the granitic peaks; snow whitened their summits, glaciers spread in their intervals, springs furrowed their sides, and the waters flowed on the earth.

In the meantime, the sea saw animals produced in its bosom. The banks of rivers, and sides of mountains, became covered with vegetables, to prepare a habitable soil. Running streams were already distributed through it, in lakes more numerous than now, because the surface was more uneven, and the plains did not yet exist. The ocean occupied them, and bathed the porphyry of Chimborazo, and of the anti-Sanica, then much higher in the skies. The high plains of Quito, and the deserts of Tartary, were covered with water, and served as a habitation for marine animals. But the diminution of the ocean was rapidly effected by different ways. The waters from the high mountains of the torrid zone, accumulated wrecks of matter. The ocean, pressed, flowed back unequally towards the poles, according to the degree of flattening, and deposited the materials of the *Secondary Formation.*

Secondary Rocks.

This extensive and interesting class of rocks, rests immediately on the transition class; but, when they are wanting, on primitive rocks; and when both occur in the same district with the secondary, they occupy a higher level. The hills of secondary districts, are lower, rounder, with gentler acclivities, and fewer cliffs, than the transition; their valleys are shallower, and their bottoms less inclined. The secondary formations are distinctly stratified, and the strata oftener horizontal, or slightly inclined, than in the older rocks. That regular direction of strata, prominent in the preceding classes, has not been observed in the secondary.

The conglomerated structure of many of the secondary rocks, presents a mechanical, and not chemical aspect; and even the limestones of this series, approach more to the mechanical formation, than those of the preceding classes.

Secondary rocks are also distinguished by their great variety and abundance of fossil organic remains. These extend through the whole secondary series, abounding in some formations, as limestone; and in others, as gypsum and trap, appearing rarely, and in small quantities. The older formations have fossil remains of oviparous quadrupeds or lizards; while, in the newer, remains of true quadrupeds, as of opossums, occur; and Werner pointed out, among the secondary formations, the gradual rise of the animals in the zoological scale, according to the date of the formation containing their remains; that in the oldest secondary rocks, the animal remains were of tribes lower in organization, than those met with in formations in the middle of the series; and, that those found in the newest members of the class, were of animals much more perfect than those in the middle part of the series.

Coal (already enumerated in the primitive and transition classes) occurs in great abundance; and, besides the glance-coal, the only kind in the primitive and transition classes, the secondary class contains also the black or bituminous coal (which has more the aspect of a vegetable formation than the glance-coal) and brown coal, a mineral of undoubted vegetable origin.

Secondary rocks are much less metalliferous than the transition and primitive, and the principal repositories of ore are the lower parts of the series, in the mountain limestone, lower part of the coal formation, magnesian limestone, and in the lower part of the new red sandstone. The metals most abundant are iron, lead, and copper; and to these, as of rather abundant occurrence, may be added, zinc, in the form of calamine, mercury in form of cinnabar, and cobalt. In the secondary class, rock-salt first makes its appearance in quantity, and in the form of imbedded masses, and beds associated with gypsum and saliniferous clay.

The gems are of still less frequent occurrence in the rocks of this class.

This class of rocks, from its variety and abundance of useful minerals, is highly interesting to those who attend to the uses of minerals. The greatest coal mines in all countries, are in secondary rocks: the richest lead mines in England; the great iron mines in England and Scotland; and the salt of Cheshire, and of other countries; the vast quarries, of sandstone, so important in building; of greenstone, which furnishes the best paving stone hitherto discovered; and of limestone, so useful for various economical purposes, are situated in the formations of the secondary class.

The principal secondary rocks are sandstone, limestone, and trap, arranged in various positions, and associated with other rocks:

1. *First Sandstone, or Old Red Sandstone Formation.*—This is a reddish-brown sandstone, principally composed of particles of quartz, either without ground, or connected together by a basis or ground of iron shot-clay. It passes into greywacke, as on the coast of Galloway. It rests upon the rocks of the transition class.

2. *First Secondary Limestone, or Mountain Limestone*—is a compact blueish grey limestone, full of encrinites, corals, and shells; often contains caverns, and sometimes alternates with the sandstone, slate-clay,

and other rocks of the coal formation. It lies immediately on the old red sandstone.

3. *Coal Formation.*—This is an alternation of grey and white sandstone, bituminous shale and slate clay, clay ironstone, limestone, and coal. The whole together form a group or set of rocks, termed the coal formation. It rests on the mountain limestone.

4. *Second Secondary Limestone, or Magnesian Limestone of Geologists.*—This formation, as it appears in England, is generally a granular, sandy, and glimmering limestone, which contains a considerable portion of carbonate of magnesia. It occasionally contains gypsum and rock-salt. It lies immediately over or above the coal formation.

4. *Second Sandstone, or New Red Sandstone Formation.*—This sandstone is principally composed of particles of quartz, set in a reddish brown clayey basis or ground. It is looser in its nature than the old red sandstone, and its colour wants the blueish tint which occurs in the old red sandstone. It is sometimes conglomerated, particularly where near the magnesian limestone, when it contains fragments of the subjacent strata. It abounds in beds of red and blue marl and clay, and in these there are occasionally imbedded masses and beds of gypsum, and rock-salt. It is here, and in the magnesian limestone formation, that the greatest masses of rock-salt are met with, and it is in these formations of the secondary series that the principal salt mines are situated. It rests immediately on the second secondary or magnesian limestone.

5. *Third Secondary Limestone, or the Oolite or Shell Limestone Formation, or Jura Formation.*—The lower members of this formation are blue, grey, and white slaty limestone, with blue slaty marl and clay, in which are variously shaped masses of chert. These are known under the name *Lias.* Above these, still in this formation, there are alternations of beds of oolite limestone, shelly limestone, calcareous sandstone, various marls, clays, and fuller's earth. It rests upon the second or new red sandstone.

6. *Third Sandstone Formation, or the Green Sand Formation.*—This formation extends through a large portion of the south-eastern parts of England. Its

characteristic member is a siliceous sandstone, abounding in grains of a substance resembling green or augite. Besides this sandstone, the formation contains beds of a coarse shelly limestone, of various clays, fuller's earth, and of iron sand. It rests upon the third limestone or oolite formation.

7. *Fourth Limestone Formation, or Chalk Formation.*—The lower part of this formation is composed of a grey clayey chalk, without flints, and of grey-coloured clays and marls. Immediately above is a hard chalk, with few flints, and above is the softer chalk in which flints and organic remains abound.

8. *Brown Coal Formation.*—In this formation, which appears to rest upon chalk, brown coal occurs in great masses, associated with clays and marls, and occasionally with glance coal. The English *pudding-stone* appears to rest immediately, either on the brown coal or the chalk formations.

9. *Paris Formation.*—Under this head we include the series of beds of clay, marl, limestone, gypsum, sand, and sandstone, that occur in the basin of Paris, and also in that of the Isle of Wight and other quarters. They lie above chalk, and higher than the brown coal, and are divided into sets; two, characterized by the presence of fresh water shells, and remains of quadrupeds, are named *fresh water formations;* and other two, containing principally salt water shells, are named *marine formations.*

10. *Secondary Trap Rocks.*—The rocks of this division have been described by many geologists as lavas. They occur in imbedded masses, beds and veins, in many of the formations already described, and hence, in order to prevent repetition, we have brought them together under one division. They are principally composed of augite, with occasional hornblende, and felspar; the augite occurs in all its states, from the crystalline to the earthy or powdery condition, and the felspar appears in all the different states, from clay stone and clay to the crystalline state. The following are the secondary trap rocks: *Basalt, greenstone, syenite, amygdaloid, porphyry,* and *tuffa.*

From this epoch, things became more stable; changes no longer were general, but merely in some regions;

1 Alluvium
2 Fresh water formations
3 Clay & Sand
4 Chalk & Marle
5 Clay Sandstone &c.
6 Oolite
7 Lias
8 Various Clays
9 Coal formation
10 Red Marle & Sandstone
11 Mountain or Transition Limestone
12 Old Red Sand Stone.
13 Greenstone Trapp & greenstone Slate.
14 Clay Slate
15 Mica Slate with beds of Marble
16 Gneiss with beds of Granular or primitive Limestone called Marble
17 Granite.

varied in aspect by the eruption of volcanoes, the sinking of ground, the draining of lakes, &c. The sea had hollowed out its proper basin, and lowered its level, by its decomposition in the focus of volcanoes; concurring to form numerous substances, particularly salts, which absorb a great quantity of water; the absence of much friction at the poles, causing defect of heat, and the water there forming the polar ices; in furnishing, by evaporation, aqueous particles to the atmosphere, glaciers to the mountains, snow to cold countries, lakes to divers basins, subterraneous water to the cavities, also filled by direct and continued infiltration. All the waters which furrowed the surface, corroded the summits, of the mountains, tossed about what they wore away, and deposited the soil of the valleys and plains, or the *Alluvial Lands.*

Alluvial Lands.

These are the various clays, loams, marls, sands, gravels, rolled masses, &c. which lie over the other more solid rocks, and which owe their origin to the agency of the waters of the ocean, of rivers, lakes, and springs. They are divided into those called *diluvian,* because they seem to have been formed at the time of the deluge; such are the clays, sands, and loams, containing the remains of elephants, rhinoceri, &c. and of those loose blocks sometimes 50,000 square feet in magnitude, and found at great distances from their native places; and into those clays, loams, sands, and gravels, which are daily formed on the face of the earth by the agency of the waves of the ocean, and the actions of rivers, lakes, and springs, and which have been named *post-diluvian.*

This sketch of the changes, whereby the earth's surface took its present form, gives an idea of the general relations among the lands. A metallic nucleus is their foundation; on this is a first covering, whose granitic base loses its homogeneity,—by degradations converting it into gneiss, schisti, &c.—contemporaneous aggregations, though incomplete, producing porphyry, amygdaloid, magnesian and calcareous rocks; or, by the interposition of combustible substances, which traverse the rocks in veins, mix with them in beds, or collect in masses. This covering, in its totality, must be separated from the nucleus by great cavities, occupied by the fluids of the atmosphere, not disengaged at the time of the rise, and by the waters of the sea, subsequently filtered in by the fissures. Externally, the lowest part of the covering supports the superimposed lands, and is a basin for the ocean. The highest part forms the nuclei, and summits of mountains, chiefly under the torrid zone, where are the highest eminences; and in the temperate zone, where also are mountains of the first order, as the mass of Tartary, Imaus, Caucasus, Alps, Pyrenees, Alleghany, Stony Mountains, &c. &c. in the boreal hemisphere; and the Magellanic Andes, the mountains of the Cape of Good Hope, in the austral hemisphere. Towards the poles, the granitic formation loses its height, as in the Krapacks, Valdai, north Oural, Daouria, and Stony Mountains; or only appears in the mean region of the mountains, as in the Dofrine.

On the borders of some of these mountains, chiefly the least elevated, are seen transition rocks, rising at times to the highest summits, as in some branches of the Krapacks, in Daouria, Derbyshire, &c. Probably such rocks may be found against the sides of all mountains, in a situation more or less inclined, arranged in beds of great thickness, but moderate breadth, which lie along the primitive rocks, and cover them on several points. The remnants of animals and vegetables are scarce in this formation, because only marine animals existed, and perhaps even only zoophytes and molluscas, when the ocean first sunk. But, for a contrary reason, metals are common, and mostly disposed in veins.

The land called *secondary*, caused by the second retreat of the waters, is mostly horizontal, and composed of heterogeneous matters. It every where covers the primitive and transition rocks; and often exceeds them, when not very elevated, as in the Pyrenees; and especially in Scandinavia, where all the summits are calcareous, and only the base granite. The shelly limestone is chief in this formation; in some places, they form links which run between, and seem to connect the masses of granite. These masses often are little covered on one side, and much on the other, which causes the slope, steep and gentle. On the latter, the secondary matters lie in greater quantity; there is found chalk, gypsum, marl, slate, argil, freestone, and the secondary trap, (of Werner) confounded with basalt; finally, deposits of divers metallic substances, as coal, bitumen, gemsalt, &c. Here also are mineral springs, very scarce in primitive lands, in which only some sulphureous waters are found, owing to the decomposition of pyrites.

All these heterogeneous matters lie in confusion, and rarely distinct from each other; which confusion has caused various accidents in the superposition; as voids, always existent, or else formed by falls, commotions, splitting of rocks, and similar phenomena, frequent in a moving soil, and little consolidated. There we find grottoes, caverns, and abysses, while the granitic masses have only slits, fissures, and precipices; caused by other matters that form veins. The blocks of granite and porphyry are split, sometimes very deep; but voids are rare; the rocks all press close against each other. The formation is identical; it proceeds from a single cause; all the inequalities rise from the same base, and having risen in a mass, cavities can only exist below it.

In the secondary formation the case is different. The beds or layers are of divers natures. When first laid over each other, they were soaked with water; the desiccation caused shrinking and consequent voids. The fluids in the cavities being more considerable in volume, and disengaged with more violence, earthquakes shewed themselves more forcibly, overturned the strata, and formed there in slits. The water, which constantly filtered into these secondary and generally porous matters, carried with it the less tenacious layers, and left only the calcareous rocks which covered them. This caused grots and caverns, frequent in calcareous rocks, and subsequently filled with stalactites deposited by the waters. Herein the transition rocks hold the middle place between the two other; and the Alluvial Lands form the extremity of this series of relations. They are massive, like the granitic covering, but obviously different; the latter having been formed successively. All here being the work of running waters, or inundations, the earthy matters, especially the sand and argil, constitute the principal mass. The rocks, decomposed by the action of the elements, become pulverized; the waters have borne along the wrecks, mixed them with fragments of stones, pebbles, shingles, bones, shells, metallic and saline particles, &c. and deposited them in the cavities. The depths have been filled, the soil has acquired extent, and has diminished the oceanic basin in proportion. But this effect was not instantaneous; it was progressive; more rapid in the commencement, afterwards it slackened, and yet continues its levelling effects.

LECTURE XXI.

STRATA OF THE EARTH.

Sit mihi fas——————
Pandere res altâ terrâ et caligine mersas. VIRGIL.

Give me, ye powers, the wondrous scenes to show
Conceal'd in darkness, in the depths below.

UPON examining the earth, where it has been opened to any depth, the peculiar appearances that occur are the different layers or beds of which it is composed. These parallel layers are of similar substances one above the other, of different depths or thicknesses, and they appear to be results of deposits of the same substances in a state of solution, or of an action like that of water, which tends to reduce all materials which are its patients to a level. This action of water appears to be the reasonable cause of the formation of most strata; but there is a mechanical action and re-action between substances of different density and bulk, arising from their centripetal force, which constantly tends to equalize their respective levels. In the present visible creation, the upper stratum consists of the fine mould of decayed vegetable and animal matter, of thicknesses proportioned to the luxuriance of the site.

This external and prolific layer is in a state of continual change. Vegetables, which are naturally fixed and rooted to the same place, receive their adventitious nourishment from the surrounding air and water: animals, which remove from place to place, are supported by these, or by each other. Both, however, having enjoyed, for a time, a life adapted to their nature, return to the earth those spoils which they had borrowed for a very short space, to be quickened again into existence. But the deposits they make are of very dissimilar kinds, and the earth is differently enriched by their dissolution. Those countries that have, for a long time, supported men and other animals, have been observed to become more barren every day; while, on the contrary, those desolate places, in which vegetables only are abundantly produced, are known to possess amazing fertility. "In regions which are uninhabited," says Buffon, "where the forests are not cut down, and animals do not feed upon the plants, the bed of vegetable earth is constantly increasing. In all woods, and even in those often cut, there is a layer of earth of six or eight inches thick, formed by leaves, branches, and bark, that fall and rot upon the ground. I have frequently observed on a Roman way, which crosses Burgundy, for a long extent, that there is a bed of black earth, of more than a foot thick, gathered over the stony pavement, on which several trees, of a very considerable size, are supported. This I have found to be nothing but the earth formed by the decayed leaves and branches, which have accumulated in time in a black soil. Now as vegetables draw much more of their nourishment from the air and water than they do from the earth, it must follow, that, in rotting upon the ground, they give much more to the soil than they have taken from it. Hence, therefore, in woods kept a long time without cutting, the soil below increases to a considerable depth; and such we actually find in those American wilds where the forests have been undisturbed for ages. But it is otherwise where men and other animals have long subsisted; for, as they make a considerable consumption of wood and plants, both for firing and other uses, they take more from the earth than they return to it. It follows, therefore, that the bed of vegetable earth, in an inhabited country, must be always diminishing, and must, at length, resemble the soil of Arabia Petræa, and other oriental countries, which, having been long inhabited, are now become plains of salt and sand; the fixed salt always remaining, while the other volatile parts have flown away."

Beneath the upper stratum usually lie others, evidently of marine formation, created by such an action as that of the sea. Beneath this, Cuvier has distinguished another layer of animal and vegetable remains; then a second series of marine strata; beneath these a third vegetable stratum; and again, a third of marine strata; all so many effects of obvious, yet remote, causes. Another cause not generally regarded, tends also constantly to create the upper stratum: viz. the dust which falls from the atmosphere, and deposits a sensible thickness in every year. Whether this arises from storms, and the action of the atmosphere, which raises the dust that falls, or whether there may not be a constant aggregation of gaseous atoms in the medium of space through which the earth moves, are questions which the observation of man may never be able to determine; but if the latter be the case, and the supposition accords with many phenomena, then the bulk of the earth may be considered as gradually increasing; and hence the remains of vegetation and other phenomena of the surface being constantly found below the level of the sea. The chief element concerned in all these formations and changes is time, as the compositions of nature often employ thousands of years.

During the settling of strata, the incumbent weight of the superior beds on the lower ones occasions the exudation of the fluid parts from each inferior bed, which descends through the next inferior bed. These exudations originally compounded with mineral particles, combine in descending through each stratum, and, after successive filtrations and combinations, produce cement, which fixes in the lowest stratum to which it will descend, and in combination with that substance generates substances of peculiar kinds. Such is the origin of the cement which forms marbles, pudding-stone, cemented gravel, &c. &c. in uniting which it is harder than the original bodies, and often transparent and beautifully coloured, according to the substances through which it has passed. It is one of those combinations which result from the silent operations of nature in the lapse of indefinite ages.

Of these beds over beds, each of them, as far as it extends, maintains the same thickness. It is found, also, that, as we proceed to considerable depths, every layer grows thicker. They are sometimes very extensive, being found often to cover a space of many leagues in circumference. But it must not be supposed that they are uniformly continued over the whole globe, without interruption: on the contrary, they are ever, at small intervals, cracked through, as it were, by perpendicular fissures; the earth resembling, in this respect, the muddy bottom of a pond, whence the water has been dried off by the sun, and thus gaping in several chinks, which descend in a direction perpendicular to its surface. These fissures are many times found empty, but are often closed up by adventitious substances, which the rain or some other accidental causes have conveyed to their cavities. Their openings are not less different than their contents, some being not above half an inch wide, some a foot, and some several yards asunder; which last form those dreadful chasms that are to be found in the Alps, at the edge of which the traveller stands, dreading to look down to the immeasurable gulf below. These amazing clefts are well known to such as have passed those mountains, where a chasm frequently appears several hundred feet deep, and as many over, at the edge of which the way lies. It often happens also, that the roads lead along the bottom, and then the spectator observes, on each side, frightful precipices several hundred feet above him; the sides of which correspond so exactly with each other, that they seem evidently torn asunder.

The chasms in the Alps are insignificant to those seen in the Andes in America. These amazing mountains, in comparison of which, the former are but little hills, have their fissures in proportion to their magnitude. In some places, they are a mile wide, and deep in proportion; and there are some others, that, running under ground, resemble, in extent, a province.

Of this kind also is the cavern called Elden Hole, in Derbyshire; which Dr. Plott tells us, was sounded by a line of 2800 feet, without finding the bottom, or meeting with water; and yet the mouth is not above forty yards over. This immeasurable chasm runs vertically down ward; and the sides of it seem to tally so correctly, as to show that they were once united. Those who visit the chasm generally procure stones to be thrown into its mouth; and these are heard for some time, falling and striking against its sides, producing a sound like distant thunder, dying away as the stone falls deeper.

In particular situations in England and France, the upper strata are bounded by a ridge of chalk (except where the sea-coast interferes), which slanting off, forms a large concave area in which they seem to have been deposited, and hence the term chalk basin, of which the most northerly includes the metropolis, and has been called the London basin, while the southern is less properly termed the Isle of Wight basin, since it includes only the northern half of that island, which is traversed east and west by the edge of the basin.

The boundary of the first of these basins may be stated generally, as a line running from the inner edge of the chalk, south of Flamborough Head, in Yorkshire, nearly south, till it crosses the Wash, then south-west to the upper part of the valley of the river Kennet, near Hungerford, in Wiltshire, and thence tending south-east to the north of the Thames, and the north-west angle of the Isle of Thanet; in all these directions, the bounding line is formed by the chalk hills; on the east side, the boundary is the coast of the German Ocean. The boundaries of the Isle of Wight basin, may be generally assigned by the following four points:—On the north, a few miles south of Winchester; on the south, a little north of Carisbrook, in the Isle of Wight; on the east, Brighton; on the west, Dorchester. It is every where circumscribed by chalk-hills, excepting where broken into by the Channel, between the Isle of Wight and the main land.

Among the substances found in these basins, none are more remarkable than the strata of bluish or black clay, which, from its forming the general substratum of London and its vicinity, is usually called London clay; it occasionally includes calcareous and siliceous sand or sandstone: and in other countries the corresponding stratum is nearly entirely a calcareous freestone; such is the *calcaire grossier*, of which Paris is chiefly built. This clay is with us remarkable for its horizontal layers of septaria, which are flattened masses of argillaceous limestone, traversed by veins of carbonate of lime, or sulphate of baryta. The London clay also affords specimens of blue pulverulent phosphate of iron, pyrites, amber, fossil, resin, and selenite; the hardness of the water found in this stratum is chiefly referable to its containing the last-mentioned substance in solution. The blue clay is also abundant in organic remains of crocodiles, turtles, vertebral and crustaceous fish, and testaceous molluscæ in great number and beauty, but differing, though often very slightly, from recent genera; yet extinct genera, so common in the older formations, are rare in this; it is said, however, that cornua ammonis and belemnites have been found. Zoophytes are likewise of very rare occurrence. Among vegetable remains there are found pieces of wood in various states, and others perforated by teredines, like those which infest the West Indian seas.

In the Isle of Sheppy there have been found in these clay strata, no less than 700 varieties of fruit and ligneous seed-vessels, very few of which agree with any known varieties at present in existence; some seem to be species of cocoa-nuts, and various spices. The greater part of the soil of Middlesex, Essex, and Suffolk, and considerable portions of Berkshire, Surrey, and Kent, consist of London clay; and in the Isle of Wight basin, it forms the whole coast from Worthing, in Sussex, to Christchurch, in Hampshire, and extends from the latter place, inland, by Ringwood, Remsay, Fareham, and passing a mile or two south of Chichester, to Worthing. The country is generally low, or only slightly undulated, and as a soil, it is productive of fine oak, elm, and ash timber, but requires chalk to render it productive in corn; when well manured, it forms excellent garden ground, as the vicinity of London amply testifies.

The history of the wells in London is very interesting, as connected with the clay formation, and they may be divided into three classes. 1. Those which are in the gravel above the clay. 2. Those in the clay itself. 3. Those which derive their supply from the strata below the clay. A great deal of good limpid water is derived from the first class, where its escape is prevented by the dense nature of the substratum. Sometimes it is rather hard, and sometimes brackish, but, generally speaking, very good drinking water. Where the diluvial gravel is very thin, or altogether wanted, there are wells sunk in the blue clay, but the water is extremely impure. Selenite is its common ingredient, and sometimes the pump delivers nearly a saturated solution of that salt. Sulphate of magnesia, sulphate of soda, sulphate of iron, and occasionally sulphuretted hydrogen, are also found in the waters from the blue clay. The third class of London wells includes those which perforate the clay, and derive their water from the strata beneath it. The water which supplies these wells rises from the sands below the London clay. The depth of these wells is, of course, dependent upon the thickness of the clay stratum.

At Whitechapel, east of London, some wells have been carried through it, and do not exceed 100 feet; at Tottenham, it is about 120 feet; in the Strand, 200 feet; in St. James's-street, 235 feet; at Chelmsford, 300 feet; and at Wimbledon, the well is 530 feet deep, and it is doubtful whether the clay is actually there pierced. By indirect examination, the greatest thickness of the clay in the London basin, has been estimated at 1000 feet.

Above the blue clay we find, in certain situations, distinct superimposed strata; thus, on the east coast of Suffolk, low cliffs resting upon the London clay are found to consist of sand and gravel, enclosing peculiar fossils; the whole mass is known by the appellation crag. Of the shells which it contains, the greater number resemble the recent shells of neighbouring seas; there are, however, a few extinct varieties, and among them the *murex contrarius;* though, what is very curious, the fossil shell with the whirls in the ordinary direction is also found here. There are likewise a few fossil bones, much impregnated with iron, and belonging to unknown animals.

This formation is seen at Walton Naze, in Essex, and caps the cliffs on both sides of Harwich, extending considerably into Suffolk and Norfolk, where it forms a fertile soil. The sandy deposits which cover certain parts of the London clay, and which are denominated Bagshot sand, must also be considered among the deposits, which geologists have lately termed the upper marine formation. Bagshot Heath, and the sand of Hampstead and Highgate, are of this description. It is, however, in the Isle of Wight, that we meet with the most interesting series of the strata above the blue clay. The cliff called Headen Hill, on the north-west coast of the island, exhibits an admirable section of these formations. This hill consists of several strata; the uppermost overlies the upper marine formation, and contains abundance of fresh water shells, without any admixture of marine exuviæ, together with seeds of a flat oval form, and parts of coleopterous insects: it has been termed the upper fresh water formation, and may be seen in many other parts of the island, especially about Cowes, Bembridge, and Binstead, and it is quarried as a building stone, between Calbourne and Thorley.

To this stratum succeeds the upper marine formation, and then we arrive at a series of beds of siliceous, calcareous, and argillaceous marls, abundant in fresh water shells, but wholly deficient in marine relics; these beds constitute the lower fresh water formation, and may be seen extending round the north side of Headen Hill, into Totland Bay. We now descend to the strata which lie immediately below the London clay. They consist of irregular alternations of sand, clay, and pebble beds, forming a series of contemporaneous depositions intermediate between the chalk and clay, and usually described under the term, plastic clay formation.

The highest northern point at which this formation is seen, is near Hadleigh, in Essex, whence it borders the clay, to about five miles south-west of Braintree. Halsted and Coggeshall, and the intermediate tract, are upon the plastic clay; it also extends from Ware to near Edmonton, over Enfield chase, and passing close to St. Alban's, skirts the London clay to Uxbridge, on the north of which, it takes a westerly direction towards Beaconsfield, and thence runs nearly south to the Thames. It is seen again at Reading, in Berkshire, and extends thence, though not in a straight line, to a few miles beyond Hungerford, which may be said to be its extreme point on the west, except a few outlying masses, south of a line from the latter place, to Marlborough, in Wiltshire. Turning south, from a little on the west of Hungerford, to the foot of the chalk hills, it passes east by Kingsclere, Basingstoke, and Odiham, in Hants, and Guildford, in Surrey; thence rather in a north-easterly direction, a little to the south of Croydon, it continues to skirt the foot of the chalk hills by Farnborough and Chatham, in Kent, and thence by Milton and Ospringe, to the foot of Boughton Hill, where it divides; passing, on one hand, in a north-easterly direction, it skirts the London clay to Whitstable, on the coast; and on the other, nearly east, to Canterbury, (which stands on the beds of this formation,) to the coast of the Reculver, whence it again passes to the south-west, except where marshy lands intervene, by Sandwich, which is built upon it, a little to the south of Deal.

The supermedial order of rocks, though admitting of several subdivisions, may generally be referred to the following classes, enumerated in the order of their succession descending from the plastic clay. 1. Chalk. 2. Ferruginous sand. 3. Oolite, including lias. 4. New red sandstone and magnesian limestone.

The chalk formation, from its extent and contents, forms one of the most remarkable and interesting features of English geology*. Where in contact with the superincumbent clay, it generally exhibits symptoms of having been exposed and worn previous to its having received that covering, as if an interval had existed between its completion and the deposition of the formations that repose upon it. The upper strata of chalk are remarkable for their layers of nodular flints, which are generally arranged nearly in a horizontal position. Sometimes tabular masses, and even veins of flint, are observed, the latter traversing the strata at various angles. Nodules of

* Among the legendary or sacred books of the Hindoos, exists one containing an extraordinary account of what the writer, in a mixture of theology and fact, calls *the great churning of the sea.* Major Wilford has published a translation of this curious document, in the Asiatic Researches; and it appears, that in the æra of the Hindoo gods, an extraordinary, or according to the author, supernatural convulsion of the sea took place, in a situation which corresponds to the present position of the North Irish Sea. The writer relates, that a white foam or cream was thrown up for many months, which filled all the neighbouring seas, and gave to Britain its name of the White Island. Doubtless, there is more fable than fact in this story; but it may perhaps have some relation to the origin of the extensive chalk formations which are peculiar to this part of the world.

pyrites, and of crystallized carbonate of lime are also found in these beds, and a very interesting series of organic remains of genera and species nearly all extinct. The lower strata of chalk are marked by the deficiency of flint and organic remains, and are commonly more or less argillaceous, exhaling an earthy smell when breathed upon, and degenerating into what is usually called chalk marl, a compound of chalk, clay and sand. Where chalk is of uniform texture, it is generally deficient in springs; but where it happens to be traversed by beds or veins of substances of softer or sabulous texture, there the water often percolates and yields an abundant supply. The fuller's earth, and sulphate of barytes of Nutfield in Surrey, together with crystals of quartz and carbonate of lime, and nodules of chalcedony and chert, are found in this deposit; it is also very abundant in organic remains. It is, however, difficult to draw any correct line of demarcation between this green sand with its accompanying clays, and the great iron-sand formation, which we see in such perfection in the cliffs at Hastings. This iron-sand, however, is comparatively scanty in organic remains, so that the green sand and iron-sand bear in this respect some analogy to the upper and lower chalk.

As an example of the mode in which the strata of the south of England are arranged, we shall give a minute description of one particular place, which is peculiarly favourable for geological observations. The strata of Alum bay, in the Isle of Wight, now seen in a vertical position, must have been originally horizontal, or nearly so. Besides other circumstances from which this appears, there are, in one of the vertical beds consisting of loose sand, several layers of flints, extending from the bottom to the top of the cliff; these have been rounded by attrition. Now it is inconceivable, that these flint pebbles should have been originally deposited in their present position: and they point out the original horizontality of the series. It appears, that between the vertical chalk hills of the Isle of Wight, and the South Downs, there is a basin, or hollow, occasioned by the disturbance of the whole mass or strata from below the chalk, to the London clay, inclusive. Hence, all the beds situated within this basin, lie above the London clay. The lower stratum is more or less argillaceous, and constitutes what is called the chalk marl. Together with the other strata, it frequently forms cliffs of considerable heights. It pulverizes in frost. The chalk-marl is never quite so white as chalk, having generally a tinge of yellow. The middle and upper strata consist of chalk of extreme whiteness and purity, and are distinguished from each other chiefly by the upper containing flint nodules. Chalk without flint is usually harder than chalk with flint. The clay and sand cliffs of Alum bay exhibit the most interesting natural sections which can be imagined. The whole have evidently been formed at the bottom of the ocean, as they all exhibit marks of marine origin. The chalk which forms the side of Alum bay, is somewhat harder than usual; and the flints are shivered so as to come to pieces when taken out. Next to the chalk in the north, is a bed of chalk-marl. To this succeeds a bed of clay, of a dark red colour, streaked with white or yellow. This is divided by a bed of white sand, from a very thick bed of dark blue clay, which contains much green earth. Next follows a succession of beds of sand.

Greenish yellow sand.
Yellow sand with ferruginous masses.
Greenish sand.
Yellow, white, and greenish sand.
Whitish sand, with thin stripes of clay.
White and yellow sand.
Light green sand.
Ferruginous sand-stone.
Yellow sand, with a few red stripes.

Next to this, and the middle of the bay, is a numerous succession of beds of pipe-clay, alternating with beautifully coloured sands.

Blackish clay, with stripes of white sand.
Sand intensely yellow.
Very white sand.
Sand of a crimson colour.
Pipe-clay, with sand stripes.
Yellow sand, with some crimson.
Pipe-clay, white and black stripes of sand.

In the middle there are three beds of a sort of wood-coal, the vegetable origin of which is distinctly pointed out by the fruits and branches still to be observed in it. It burns with difficulty, with very little flame.

Yellow and white sand, with crimson grey stripes.

Five beds of coal, similar to that already mentioned, each a foot thick.

Whitish sand, and brownish pipe-clay.

Whitish sand, with stripes of deep yellow.

Layers of large water-worn black flint pebbles, imbedded in deep yellow sand.

A stratum of blackish clay, with much green earth and septaria. In this earth are numerous fossil shells, in a very fragile state. To the north of Alum bay is the hill called

Headen, 400 feet high, composed of the same horizontal strata of which the north part of the island consists. In this hill is distinctly seen the alternation of marine and fresh-water deposits.

The lower fresh-water formation, appears in a series of sandy calcareous and argillaceous marls, sometimes with more or less of a brownish coaly matter. Some of them appear to consist of fragments of fresh-water shells, many of which are sufficiently entire to ascertain their species. These are the lymneus, planorbis, and cyclostoma, and perhaps the helix; with a bivalve resembling the fresh-water mytilus. These beds lie immediately upon the black clay, which covers the white sand already noticed. The quantity of shells is by much too considerable to suppose that they could have been carried by rivers or streams into an arm of the sea; and in this case there would probably have been an intermixture of marine shells. We are compelled, therefore, to suppose that the spots where they now are were once occupied by fresh water, in which these animals existed in a living state. Fresh-water strata occur in other parts of the Isle of Wight. Over the lower fresh-water formation in the Isle of Wight, a stratum occurs, consisting of clay and marl, which contains a vast number of fossil shells wholly marine. At Headen, it appears half-way up the cliff, and about thirty-six feet thick. The shells are so numerous that they may be gathered by handfuls, and are in general extremely perfect. From their delicacy and perfect preservation, it is probable they lived near the spots where they are now found. Immediately above the last stratum, is a thin bed of sand of six inches, upon which rests an extensive calcareous stratum of fifty-five feet in thickness, every part of which contains fresh-water shells in abundance, without an admixture of marine exuviæ. Many of the shells are quite entire. This place must have been the bosom of an extensive lake in some period far antecedent to human history; and the earth must since have undergone various revolutions, as these, instead of being now in a hollow, are at the top of a hill*. Over this bed is a stratum of clay of eleven feet in thickness, containing fragments of a shell of

* An instance of the gradual formation of a basin may be seen at this day at Whittlesea Mere, which till lately consisted of a fresh-water lake, ten or twelve miles round, but has recently been drained by art, when its bottom was found to consist of finely triturated vegetable remains, constituting a black clay, of the consistence of butter or new cheese, to the depth of several hundred feet, increasing in hardness as in depth, the whole being filled with fresh-water shells and vegetable remains

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the bivalve kind. Above this stratum is the alluvium, which here, besides vegetable earth, clays, marls, and sand, has a vast quantity of rounded siliceous pebbles of various kinds.

The district on which the capital of France is situated is, perhaps, the most remarkable that has yet been observed, both from the succession of different soils of which it is formed, and from the extraordinary organic remains which it contains. Millions of marine shells, which alternate regularly with fresh-water shells, compose the principal mass. Bones of land animals, of which the genera are entirely unknown, are found in certain parts; other bones, remarkable for their vast size, and of which some of similar genera exist only in distant countries, are found scattered in the upper beds. A marked character of a great irruption from the south-east is impressed on the summits, (caps) and in the direction of the principal hills. In one word, no canton can afford more instruction respecting the last revolutions which have terminated the formation of the present continents. It appears that the country round Paris is, in many respects, similar to the country round London; they both rest upon chalk as the foundation rock, and over this chalk are beds of clay and marl, containing the remains of fresh-water shells and of large quadrupeds: the principal difference consists in the gypsum and millstone, which are local formations, and are not found in the chalk districts of England. Though chalk is the foundation rock of the country for a considerable extent round Paris, it only rises to the surface in a few situations, being covered by the other strata in the following order:

1. Chalk and flint.
2. Plastic clay and lower sand.[1]
3. Coarse limestone, or calcaire grossiere.
4. Lower marine sand-stone.

In some situations, on the same level with 3, 4, is a bed of calcareous stone, penetrated by silex, without shells; it occupies the place of 3 and 4, where it occurs.

6. Lower fresh water strata.
7. Gypsumous clay, and gypsum containing bones of quadrupeds.
8. A bed of oysters.
9. Sand and sand-stone, without shells.
10. Superior marine sand-stone.
11. Mill-stone without shells and argillaceous sand.
12. Fresh-water formation, including marls, mill-stone, and fresh-water shells.

13. Alluvial soil, ancient and modern, including pebbles, pudding stone, black earth (*les marnes argilleuses noires*) and peat.

The total thickness of the different beds and strata over the chalk, as given in an ideal section of the country, is about 160 yards, or 490 feet. The plaster quarries at Montmartre, in the environs of Paris, are celebrated for their numerous and remarkable organic remains. Montmartre is elevated about eighty yards above the level of the Seine. The summit is covered with vegetable earth, under which is a bed of sand mixed with pebbles of flint. Horizontal strata of marl, earthy limestone, and gypsum, succeed each other. The following are the inferences which Cuvier and Brongniart have drawn from the organic remains of marine and fresh-water animals found over each other at this place; they suppose it has been alternately covered by different accumulations of salt and fresh water.

1. A sea which deposited an enormous mass of chalk, with moluscous animals of a particular species.

2. The sudden variation of this deposition, and the succession of one entirely different, (*d'une toute autre nature*), which deposited only beds of clay and sand. Fossil wood is discovered in these beds.

3. Another sea soon succeeded, (or the same returned again), producing new inhabitants; a prodigious quantity of testaceous molusci, different from those in chalk, form thick beds at the bottom of this deposition, which are principally composed of the covering of testaceous molusci, (*des envelopes testacées*). This sea soon after returned.

4. The surface was covered with fresh water, (*eau douce*), and beds were formed, alternating with gypsum and marl, which enveloped the debris of animals bred in the lakes, and the bones of those living on its banks.

5. The salt water returned, and supported first a species of animals with bivalve shells, and others with turbinated shells ("coquilles turbinatées"); these shells ceased to be formed, and were succeeded by oysters. An interval of time elapsed, during which, a considerable deposition of sand took place; no animals then existed in these lakes, or their remains have been entirely destroyed.

6. The various productions of the second lower sea ("la mer inférieure") re-appear, and we find on the summit of Montmartre, Romanville, &c. the same shells which occur in the middle of the coarse earthy limestone ("calcaire grossiere").

7. At length the sea entirely disappeared for the second time from the lakes, and pools of fresh water ("mares d'eau douce") supplied its place, and covered with their inhabitants almost all the summits of the adjacent banks, and the surface of some of the Plains which separated them.

The third of the four subdivisions of the supermedial rocks, namely, the oolitic series, is chiefly important as the great repository of the principal architectural materials which the island affords, and may be generally described as consisting of a series of alternating oolitic limestone, of calcareo-siliceous sandstones, and of argillaceous and argillo-calcareous beds, repeated in the same order. Three of these systems appear to comprehend all the beds which intervene between the iron sand and the new red sandstone, and each system lies upon a thick argillo-calcareous formation, constituting a well marked line of demarcation, the oolitic rocks of each system forming a distinct range of hills separated from those of the other systems by a broad argillaceous valley. In England, these formations occupy a zone, having nearly thirty miles in average breadth, extending across the island from Yorkshire on the north-east, to Dorsetshire on the south-west: they are characterized by peculiar organic remains, among which we discover many extinct genera of oviparous quadrupeds, apparently inhabitants of salt water only, various vertebral fishes, testacea of all descriptions, coralloid zoophytes, encrinites, &c. The whole of the oolitic series reposes upon argillaceous deposits, the uppermost of which are deep blue marl, with a few irregular beds of limestone, which increase in frequency as we descend, and present a series of thin stony beds separated by narrow argillaceous layers. These beds are known by the name of lias; they are argillo-calcareous, while the blue or grey lias contains oxide of iron, and forms, when calcined, a strong lime, distinguished by its property of setting under water. Organic remains are here very abundant and interesting; they embrace more vertebral animals than are found in any other formation; among them are two remarkable extinct genera of oviparous quadrupeds, the ichthyosaurus, and the plesiosaurus.

The strata which intervene between the lias and the deposits of coal, are referable to two formations very intimately connected together, viz., 1st. a series of marly and sandy beds, intermixed with conglomerates derived from older rocks, containing gypsum and rock salt: and 2dly, a calcareous formation, often breciated, and containing magnesia, lying below or in the lower portion of the above series. The former deposits are commonly called red marl, or new red sandstone; the latter, magnesian limestone.

The series of rock formations included in the medial or carboniferous order, admit of the following subdivision: 1. Coal. 2. Millstone grit and shale. 3. Carboniferous, or mountain limestone. 4. Old red sandstone: and in forming an accurate notion of the geology of our coal districts, we shall be much assisted by keeping in view the mutual relations and connexions of these four substances; remembering, always, that although carbonaceous beds occur in other formations, it is only in the limits of the strata at which we have now arrived, that supplies of coal capable of being profitably worked are to be found.

This whole series reposes upon an important assemblage of strata, chiefly calcareous, and from its association with coal, is called carboniferous limestone; as it forms considerable hills, and is rich in metals, the terms mountain and metalliferous limestone, have also been applied to it.

It is the principal depository of the British lead mines, those of Northumberland, Durham, Yorkshire, Derbyshire, and Cumberland, being all situated in it; it also affords ores of some other metals, and a variety of beautiful crystallized minerals.

The strata of carboniferous limestone exhibit all the irregularities of the accompanying coal measures; they are often greatly inclined, contorted, and dislocated: and, when they alternate with argillaceous strata, they generally abound in springs, which break out often with singular impetuosity. The hot springs of Buxton, Matlock, and Clifton, are upon this formation; the waters are generally remarkably pure and pellucid, though sometimes so loaded with carbonate of lime, held in solution by excess of carbonic acid, as to deposit it, as a tufa, upon the adjacent rock; or incrust substances accidentally immersed; such are the petrifying springs of Matlock, Middleton, &c.

We now reach the lowest member of the carboniferous or medial series of rocks, which, from its priority of deposition, is termed old red sandstone; it is sometimes separated from the limestone by a layer of shale: it is a mechanical aggregate, constituted apparently of abraded quartz, mica, and felspar, containing fragments of quartz and slate; sometimes its texture is slaty and fine-grained; at others it passes into a conglomerate.

Mr. Middleton, in another and popular view of this interesting subject, in which he takes no cognizance of Webster and Cuvier's theory of chalk basins, states that the *British strata* are arranged nearly in the following order:

1. *Vegetable mould,* a foot or two in thickness.

2. *Brick earth,* a few feet in thickness, as in the brick-fields near London, and many other places, but by no means generally.

3. Beds of *shells, sand,* and *gravel,* from five to

thirty feet in thickness. These are exposed to view in the cliffs on the coast of Essex and Suffolk. The shells and sand have been mostly washed off in Middlesex and Surrey; but the gravel, a few feet in thickness, remains, and it is used for making and repairing the roads. In some places it is a free sandy gravel, and in other places it is mixed with a chestnut-coloured clay. The greater part of the materials which compose this stratum have been formed in the places where we now find them; but such of them as consist of rounded pebbles have been fragments of older strata, broken and rolled to their present situation by the ocean. This stratum is known to extend over Middlesex and Essex: as well as the north side of Surrey, some parts of Kent, Hertfordshire, Buckinghamshire, and Suffolk; it is also met with at Hartley-row, on the road to Basingstoke, at West-Cowes, on the north side of the Isle of Wight, and many other places; but with interruptions and displacements, by being occasionally washed away.

4. *London clay.* Immediately under the foregoing formation, is a clay stratum of from one or two hundred to nearly three hundred feet in thickness. Its colour at the top, and to the depth of five or ten, and occasionally to fifteen or twenty feet, is a chestnut. At that depth, the fissures of this stratum become stained with sky blue; and, at thirty or forty feet from the top, the whole substance of this clay is of a lead colour. The depth of colour increases with the depth of the stratum to a much darker blue, or even to verge on a dull black.

This blue clay contains septaria, (balls of indurated clay, iron, and spar,) in nodules and layers; as well as occasionally many crystals, resembling icicles, three or four inches in length. These septaria balls, on being reduced by the hammer, then burned in a lime kiln, and ground, produce Parker's addition of about fifty per cent. of siliceous sand, previously washed till it is free from animal, vegetable, and earthy, matter, and then to be properly watered, worked, and used in a state of mortar, to make an excellent cement for walls of every kind. Or any sound wall, by being plastered over with it, receives a coat which becomes an actual stone of the harder

Roman cement. This stratum of clay also contains, not far below the surface of it, the tusks of elephants, the bones of animals, and petrified wood; and it prevails near the surface of the ground through Middlesex and Essex, the northern parts of Surrey, on the hills above Hurley, in Berkshire, at Hartley-row, and the north side of the Isle of Wight, in Hampshire, as well as in Buckinghamshire and Kent, through Suffolk, Norfolk, and farther northward along the east coast.

When good spring-water is not to be met with above this soil, it is not to be obtained without digging through it, as well as through a stratum of marine shells, which lie under it, into the sandy subsoil. Every interstice of that sand is full of excellent water, and it usually rises in the well to a considerable height, even in many cases to overflow the surface.

The road dug through Highgate-hill was wholly in this clay, and the works at that place brought to light many petrifactions. Among the rest was a tree thirty or forty feet below the surface, which evidently shewed that worms had eaten their way through it in every direction, and that the cavities occasioned by them were nearly filled with mineral matter. An elephant's tusk was found in this clay, not far below the surface of it, by the workmen employed in a brick-field at Kingsland. This tusk was rather thicker and more bent, but not longer, than those of the living animals at this time.

5. A stratum of *shells, pebbles,* and *sand.*

A bed of *shells,* consisting of oysters and cockles, though mostly the former, sometimes whole, but more frequently in fragments. These shells are cemented together by the lead-coloured London clay, and the glutinous remains of fish. They compose a layer of two or three feet in thickness. Under that there is generally eight or ten feet of a chestnut-coloured loam, containing a few sea shells, reposing upon another bed of compact shells a foot or two thick. The whole of this formation is about twelve or fifteen feet in thickness.

This bed of shells has been seen in many places, but it is not supposed to exist universally; for instance, it does not appear in the pits for fire-clay at Ewell, nor in those for tobacco-pipe clay in Purbeck. But it is said to be invariably found under the London clay, in sinking wells of considerable depth in Middlesex and Surrey. In the place of these shells at Ewell, where they were expected to basset, or rise gradually to the surface, the fire-clay is found, in two or three layers of different qualities, rising from under the edge of the London clay. The uppermost of these beds is of a reddish or ruddy colour, with blue veins. The next is a bed of clay, about three feet thick, not much unlike fuller's earth, and this rests upon sand of a similar brown colour. That is, the lowest bed of this fire-clay lies upon the upper bed of Blackheath sand, beneath which may be seen the lower bed of white sand, and under that the chalk. The foregoing fire-clay rests upon the Blackheath sand, which forms the immediate covering of chalk.

A short account of the *Norden Clay Pits* in Purbeck, owing to their producing great quantities of the best pipe-clay, may be here properly introduced. This clay is in a similar situation to the fire-clay at Ewell. The pits are dug in a tract of barren land, and situated about one mile north-west from Corfe Castle. A section of one of the pits exhibits the following appearance.

1st.	Vegetable mould, a peat earth, producing heath	1 ft. thick
2nd.	White clay and sand, in patches	5 ft. thick
3rd.	Sand, stained with iron, of a chestnut colour	10 ft. thick
4th.	Iron and stone	1 ft. thick
5th.	Ash-coloured clay, with patches of coal. This colour may be attributed to the stain of the coal	10 ft. thick
6th.	Coal, stained, in patches, with white clay. This coal is said to be unfit for domestic use, owing to its sulphureous smell	3 ft. thick
7th.	Pipe clay, white and compact, in two beds; divided by a layer of chocolate-coloured clay, one foot thick; the lower bed is esteemed the best.	17 ft. thick
8th.	Sandy clay of the same white colour as the best; it is nearly dry to three feet deep, and below that the springs prevent any deeper search	3 ft. thick

The very best white clay is the only sort sent to market from this place.

This clay is on the north side of a lofty chalk down, towards which it ascends and feathers out so as to be lost, at one hundred yards or more from the skirt of the down. The coal which covers the clay obviously originated from timber and other wood; the specimens submitted to examination were found to contain a portion of mundic and sulphur.

Blackheath sand lies under the foregoing bed of marine shells. The upper part of this formation consists of pebbles of the size of horse-beans, marbles, and walnuts; they are of many colours*, and vary in depth from a foot or two, to ten, fifteen, or twenty feet. They form the surface at Blackheath, Woolwich, and other places in Kent, as well as on Shirley common, Addington-hills, and Croomhurst, in Surrey; and they are to be seen in many other places. The pebbles are nearly free from earthy mixture, and, where they form the surface of the soil, it is extremely unproductive. Loose sand lies immediately under them; it is of a fawn colour, and ten or fifteen feet in thickness; beneath that is thirty or forty feet of sand, nearly white, which is dug in the pits, at Shirley, in Surrey, but only to the depth of fifteen feet; it continues to a greater depth, but the rest of it is drowned in water.

Under London, and in the neighbourhood of that city, as well as wherever this formation happens to be in a low situation, it is full of water; but, where it rises to the surface, it is dry sand. A fine section of it, upon chalk, may be seen in a large pit at Upper Greenwich, very near Blackheath, in Kent. It may also be seen to rest upon chalk, on the south side of Addington-hills, Croomhurst, and other places in Surrey. The sandy part of this formation lies between the fire-clay and the chalk in brick and tile fields, on the side of the roads at the east end of Ewell; it is believed to lie under the pipe-clay of Purbeck, but in these places the pebbles are found to be missing. It also rises from under the lead-coloured clay of London, and forms the surface across the middle of the Isle of Wight, in a direction from east to west. It is found in the same position in Studland Bay, Purbeck, but it is not universally found upon chalk; as the places are very numerous in which different shades of chestnut-coloured clay is the immediate covering of chalk. But, wherever this formation exists, it lies upon chalk, and it rises to the surface, or bassets out on the London side of all the chalk hills.

The excavation at Highgate, for the archway, or tunnel, passed at so great a depth in the London clay, as to cut through it, and break up the marine bed which lies under the clay. In this marine bed were found many fossil oysters,

* Such as ashes, cream, cornelian, &c.

lobsters, shark's teeth, mackerel, muscles of one inch in length, and masses of other perfect shells, one-fourth of an inch in diameter. The two last sort of shells were in some instances cemented to the clay-balls, called septaria.

The bottom of the excavation which failed under Hornsey lane, is not many feet above the stratum of chalk.

6. *Chalk.*—This formation is the next older stratum, and that it is a marine sediment is proved by its containing the shells of oysters, muscles, cockles, sharks' teeth, and upwards of fifty other fossils. The state in which these fossils are found, prove, says Mr. Parkinson, " the matrix in which they are imbedded, was formed by a gradual deposition from the surrounding fluid, which entombed these animals while living in their native beds." The stratum is now of various thicknesses, up to eight or nine hundred feet; soon after its formation, or before it was fully compressed, it must have exceeded a thousand feet in thickness. It is porous, loose, and dry, near the top; but at greater depths it is compact. At two-thirds, or three-fourths, of its depth, is obtained hard chalk tinted brown; which is broken and burnt into Dorking lime. The lower beds of chalk, like most other strata, increase in hardness, in proportion to their greater depth, until it becomes stone. Within a few yards of the bottom of this formation, there are one or more beds of it so hard, as to be nearly equal to the best Portland stone. But, as an exception to the usual order of things, this hard stone, in Merstham Quarry, lies on a bed of soft easy-working stone, called fire-stone, which is three or four yards in thickness. This stone is calcareous, and of a deep cream colour. It is dug and squared at Gatton, Merstham, and Godstone, at per cubical foot, for the London masons, who use it in fire-places. The upper parts of the chalk stratum, to about six hundred feet in thickness, contain layers and nodules of black glossy flint; and the lower parts of it, which are two or three hundred feet in thickness, contain flint of an ash-grey colour.

The Foreland, between the bays of Studland and Swanage, in Dorsetshire, shews a pretty good section of the chalk stratum; in that place, three of us estimated the chalk with black flints to be six hundred feet, and the lower beds to be two hundred feet in thickness. High-down, at the south-west corner of the Isle of Wight, is all of the chalk formation, and it rises 700 feet above the sea. This chalk mountain has been rent from the horizontal chalk stratum; on that occasion, one edge of it has been turned up, and the other down, until the strata settled in a vertical position. This movement included two beds of clay, and many of sand beneath the chalk; these are vertical, and exhibit all the colours of the rainbow adjoining the Downs in Alum Bay.

The lower beds of the chalk formation, and every fissure in them, are, with few exceptions, completely filled with water. All the rain and snow which fall upon chalk, percolate downwards to its base, where the water is stopped by a sub-soil of blue clay; and that occasions it to accumulate in the chalk, until it rises to such a height as enables it to flow over the surface of the adjoining land. In this manner are formed the springs and rivulets which issue near the foot of every chalk-hill. In the Cove, at West Lulworth, are fine fresh water streams from the base of the adjoining mountain of chalk, just above the level of the sea. The water which issues from the chalk at Croydon, Beddington, and Carshalton, forms the river Wandle; and the same thing happens at Ewell, Merstham, and other places.

Mr. Hilton Joliffe made a culvert several hundred yards in length, from a level so low as to pass through his works in the chalk at Merstham, by which a rivulet of water, sufficient to turn a mill, is constantly running off. This culvert drains the water off so as to enable him to raise the lower beds of the chalk stratum; these consist of chalk stained with iron, to burn for Dorking lime; of a stone, which is supposed to be nearly equal to Portland-stone; and fire-stone, lying immediately under each other, without any intermediate matter, and in the order in which they are mentioned. The chalk stratum passes under London, at the depth of three, four, or at the most within five, hundred feet. It is said, that the chalk stratum was found at the depth of one hundred and eight feet, in sinking a well at the Victualling-office, Deptford. It gradually rises to the surface in about ten miles, as at Croydon and other places; it then lies immediately under a thin vegetable mould, and continues to ascend for eight or ten miles more to the south; there it has attained its greatest height, and forms a range of stupendous hills on the north side of the town of Folkstone, Ashford, Maidstone, Wrotham, and Westerham, in Kent; Godstone, Reigate, Dorking, Guildford, and Farnham, in Surrey; as well as on the north side of the

South Downs, in Sussex; and above all the precipices of chalk stratum in England.

Indurated chalk stained with iron for Dorking lime, (a rock which is supposed to be nearly equal to Portland-stone, and fire-stone), may all be obtained wherever there is chalk. Where that stratum rises into high precipices, these things may be obtained at the easy rate of quarrying near the bottom of such steeps; and in all other parts of the chalk stratum, by sinking a mine to the place where they repose, near and at the bottom of it. At Denbies, near Dorking, Surrey, such a well was sunk, on the top of that high hill, to the depth of four hundred and forty feet, and there obtained a full supply of fine water; if the object had been stone, it would have been found at the same depth.

7. *Clay of a deep blue colour, and calcareous as chalk.*—A section of this clay, well defined, measured fifteen feet; towards the bottom of the bed it is rather laminated. There is a lower bed of it, but so much mixed with sand, as to render it rather of a lighter colour than the above; and this is fifteen feet thick. These formations of clay were seen immediately under the chalk, near the Chine, at St. Catherine's, and at Compton-down, on the south-side of the Isle of Wight, and on the north side of Swanage-bay, as well as at Lulworth Cove in Dorsetshire. This stratum lies immediately under the chalk, and riseth to the surface, on the south side of the Downs in Surrey and Kent; as well as on the north side of the South-downs in Sussex; it every where forms a soil of so dark a blue colour, as induces the country people to call it black land. The specimens of this formation, which have been examined, shew that it is a clayey marl, which effervesces very freely with acids.

This formation of clay lies between chalk and sand of great depth; therefore, it is obvious, that the places are very numerous, in which much of the vast quantity of water, now lodged in the lower beds of chalk, might be passed through this tenacious stratum into the sand under it, by the easy means of boring a sufficient number of large auger holes, a few yards deep. To illustrate the formation and arrangement of strata, we have annexed engravings of two sections of the strata, as it bassets or comes to the surface, nearly across the island, and another representing the alternation of strata, at a coal-pit in Cumberland, and they merit the close attention of the student.

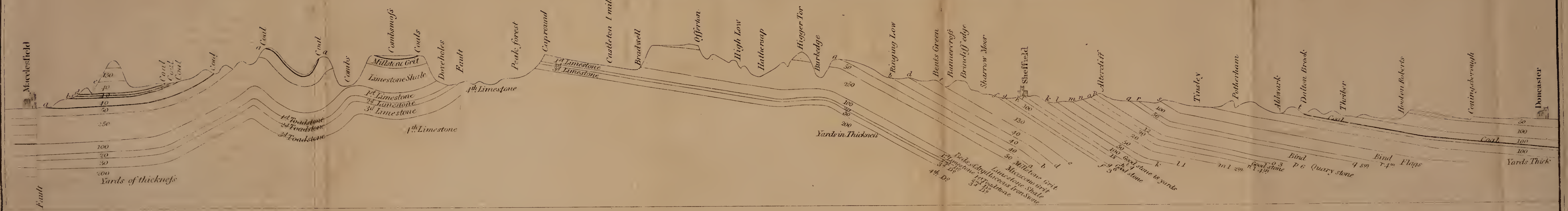
In general, our English rocks agree with the order of those found on the continent. But our greywacke rests immediately upon transition limestone, without the intervention of transition trap; and our transition flinty slate, does not occur between the old red sandstone and the greywacke. In superposition, Werner enumerates ten rocks between the transition formation and coal, namely, old red sandstone, first floetz limestone, floetz gypsum, variegated sandstone, second floetz gypsum, shell limestone, third sandstone, rock salt, chalk, floetz trap, coal. In this country the order is, old red sandstone, mountain limestone, coal. Hence it would seem, that eight rocks, out of the ten, are wanted. But this is not the fact. The first floetz limestone of Werner, which on the continent rests upon the old red sandstone, is identical with the English magnesian limestone, which is *above coal.* So that our mountain, or Derby limestone, is not in the Wernerian arrangement.

The rock so common in Derbyshire, and many other parts of England, is named mountain limestone, to distinguish it from some other limestones, which, though agreeing with it in the character of forming considerable elevations, differ from it in point of composition and geological situation. It is a secondary rock, abounding with marine shells, and is intersected by numerous metallic veins, chiefly of lead, and, more rarely, of copper. It is associated with more compact varieties, which, as they admit of a high polish, and are sometimes beautifully variegated, have obtained the name of marble.

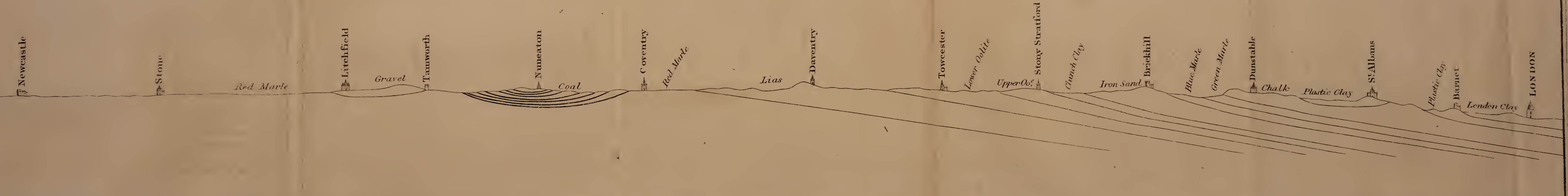
The mountain limestone formation consists of many beds of rocks, which differ greatly, both in aspect and chemical composition, and are sometimes interstratified with basalt, marl, clay, sandstone, and even coal.

The mountain limestone tract of Derbyshire, extends from Castleton, its most northern point, to about 25 miles south of that place.

A SECTION OF THE LAND FROM DONCASTER TO MACCLESFIELD.



A SKETCH OF THE LAND FROM NEWCASTLE TO LONDON.



Its mean breadth is 15 miles, and its form on the surface, is very irregular. The surface of this district is occupied by the outcrop of four strata of limestone, and of three beds of toadstone, which lie between the beds of limestone. Upon the upper bed of limestone, rests a stratum of shale, and upon the shale reposes a bed of gritstone, the basis of a coal deposit. All these beds have a general direction from north to south, and dip in most places towards the east. (See the Plan.)

The lowest stratum of limestone, whereon Peak Forest and Buxton are situated, passes across Dove Dale, and Wetton Dale. The Weaver Hills, Caldon Low, and indeed, all the limestone hills of Staffordshire consist of it. Specimens are to be seen at every lime-kiln in this neighbourhood. It is remarkable for a bright scaly fracture, and being sonorous, when struck.

The lime produced from this lowest bed, is preferred to those above it, as it burns white. In it are many caverns, as the immense one called Elden Hole, the Devil's Hall, Pool's Hole, and many others, of less note. The thickness of this lower stratum is not known, never having been pierced through; it is divided into a number of subordinate beds, several of which are of considerable thickness, and differ in their qualities; some of them are divided by thin beds of clay. Small entrochi, numerous anomia, cardia, and other organic remains, occur throughout the whole of this stratum.

We now arrive at a rock which has excited great attention among geologists and mineralogists. It is doubtful whether the toadstone is stratified, in a regular way, between the four great beds of limestone, or not. Some say, they are true and regular, that the average thickness of the two lower beds is 75 feet, and the upper bed 60, while others maintain that it is not stratified at all. It is certain, that each of the limestone beds enclose masses of toadstone, (which are not connected with any regular bed of that rock) in several places very thick, and, in others, thin; which has given rise to the suspicion that they are not stratified. (See the Plan.)

The toadstone is ferruginous, contains spots of calcareous spar, from the size of a pin's head, to that of a hazel-nut, or larger: these nodules, when exposed on the surface, fall out, leaving the imbedding substance with a porous aspect. Its general resemblance to the back of a toad, gave rise to its familiar name. A hard variety is sometimes found, which has a tendency to assume the shape of basaltic columns, and contains hornblende, and red jasper. Occasionally, it is slaty, but never contains any traces of vegetables, or shells, which occur so plentifully in the limestone, which it intersects. It generally divides the veins of lead ore which pass through the limestone.

The peculiarities of this substance have led many to suppose it a volcanic product, or lava, forced, by subterranean fire, between the seams of limestone, where it cooled and hardened, and is now rapidly decomposing. Such an explanation of its origin, though not without its difficulties, is, perhaps, better than any other.

The second stratum of limestone, about 210 feet thick, consists of many beds, the uppermost very black, and capable of a high polish. They contain great quantities of corals and shells, and, being variously tinted with iron and bitumen, make beautiful tables and chimney-pieces. Masses of black chert, shells of the genus anomia, and madrepores, also occur in it.

To this succeeds another bed of toadstone, above which is the third limestone; which, like the two preceding, consists of many beds, whose aggregate thickness is about 150 feet; and it is remarkable, that some are of magnesian limestone. In some places, the upper beds partake so greatly of the nature of chert, as to be unfit for the purposes of the lime-burner. Here and there, are masses of white chert, full of entrochi, which are sent to Staffordshire, for the use of the potter's mills. At the bottom of the stratum is a fine black marble.

Above this is found the third toadstone, and on that, reposes the upper limestone, like the preceding, about 150 feet thick; in it, as in the three lower strata, some thin beds of clay are found. In the middle beds, vast quantities of entrochi are found, and where they basset out to the surface, masses are ploughed up from the alluvial soil, exhibiting casts of the inside of entrochi, in chert, called screw stones.

The appearance of dislocation, and separation, in the mountain limestone, is very striking, and shew the convulsions the earth has undergone. The whole of the Derbyshire limestone is broken, by what is called the great fault, which extends in a very long and circuitous line. (See the Plan.) Limestone mountains are often perpendicular, and overhanging; presenting bare rocks, in a great variety of forms. The prodigious caverns which occur in them, have always been considered as objects of curiosity and admiration. Some of them have a spacious entrance, whilst others are only discovered by mining. They generally assume an arched appearance; the sides rising nearly perpendicular, while the bottoms are more flat. Large detached masses of limestone lie at the bottom, in rude forms. Caverns are found in the interior, above 200 feet high, and some probably higher. The roof and walls, in many of them, are covered with stony concretions, forming the most fantastic figures; most of them have a stream of water at the bottom, and a deposit of sand and rounded stones; which proves that water has many unseen, subterraneous courses, and, probably, was a principal agent in forming these caverns.

LECTURE XXII.

GEOLOGICAL CHANGES.

This gorgeous apparatus! This display!
This ostentation of Creative Power!
This theatre! What eye can take it in;
By what divine commandment was it raised,
For minds of the first magnitude to launch,
In endless speculation, and adore! YOUNG.

CHANGE is the characteristic of nature. The activity of the atoms of gas which compose the atmosphere, permit no body, nor any part of the earth's surface, to remain in the same state. Thus, polished metals are corroded, the colours of bodies fade, surfaces universally decay, and the most solid bodies are by this unceasing activity reduced to powder.

Variations of temperature at different seasons of the year, and altered states of atmospheric moisture, aid also the ordinary action of the atmosphere, and great winds, increase and accelerate the changes from ordinary causes.

But another agent equally active, and whose operations are more obvious, is water, which in its descent from the clouds, in the form of rain, and to the sea in the channels of rivers often too narrow to contain it, and in seas and oceans subject to flux and reflux, and to storms and tempests, constantly changes every part of the surface, and washes down the mountains and fills up the valleys.

Vegetation is also another operative cause of great changes. Thus woods allowed to decay and fall during a series of ages raise the soil on which they grow, into hills and mountains, till they are too high for other trees of the same kind to succeed. Again, the vegetation of meadows and banks of rivers, by falling crop upon crop during many successive ages, form rich super-strata, and create banks which narrow the bounds of the parent stream.

Heat, from the union of minerals in certain situations, also generates volcanic fires, which, when developed at the surface in contact with the atmosphere, have produced great and astonishing changes; but these being for the most part exhausted and burnt out, are less operative now than in earlier stages of the present arrangements, or at least of the existence of the surface as we now find it.

All the above causes are themselves so many results of the special motions of atoms, the operations of which are never-ceasing causes of creation and change. But there is another cause of changes on the earth's surface more general, more destructive of old forms, and more creative of new ones than either of those which have been named. We allude to the motions of the earth as a planet, and to the progressive changes which take place in the directions of those motions, by which changes the great oceans are made to operate on the land so as to destroy old continents and islands, and with their materials create new ones. The following are the deductions which Sir Richard Phillips has drawn on this most curious and interesting subject:

1. That the changes on the earth's surface, and the consequent phenomena of the strata upon strata, and the fossil remains, are to be referred to certain known variations of motion of the earth as a planet.

2. That those motions are the revolutions of the perihelion point, (or line of Apsides) in 20,900 years, producing opposite effects in both hemispheres every 10,450 years; and the diminishing obliquity of the ecliptic, at least at the present rate of a degree in 6900 years.

3. That the perihelion or greater forces, in varying their declination, as interchanged cause and effect, gradually accumulate the seas in that hemisphere to which they are perpendicular, and that the gradual accumulation takes place in either hemisphere, while the point of greatest force advances through twenty degrees of declination in a period of about 3488 years.

It is well known that the earth moves round the sun in an elliptical or oval orbit, the longest diameter of which is called the line of apsides, and that the sun is in one of the foci or one of the two centres of the ellipsis or oval. The distance between the foci is 3,236,000 miles, consequently the earth is that distance nearer in one part of its orbit than at the opposite part. The nearest point is called the perihelion, and the more distant point, the aphelion. But these points are not fixed; for to arrive at either point in every revolution, the earth must move a little further before it arrives at the exact perihelion, or aphelion distance, and this quantity is 19′ 40″ in a century, making a quantity equal to the whole ecliptic in 20,931 years, or from tropic to tropic in 10,465 years. Now then, if we consider the cause of these variable distances of the earth from the sun, we shall find that that cause becomes exceedingly operative on the surface of the earth. The impulses of the sun on the medium of space which carry forward the earth in its orbit, are constant and uniform; for the lines of apsides of the different planets are in different points of space, and continually changing: consequently, the variations of distance arise from variable energies in the planets themselves. But the only variable force upon a planet is the waters, and an increased energy of these will increase the energy of the earth, and diminish the length of the terrestrial lever, or distance from the sun; and we actually find that the parallel of the perihelion point at the present time is 23° south, corresponding with the great body of waters in the southern ocean. The seas, however, by their own oscillations enlarge their own bed, and destroy the land. As therefore the perihelion point progresses northward, the sea enlarges its own bed, and in a different direction as it progresses southward, so that all the lands in both hemispheres are alternately submerged every 10,465 years; hence those alternate strata of marine and land remains are generated, which without this explanation are so astonishing and inconceivable.

Action and re-action between the sun and earth being always equal, and the masses being the same, it is evident that if the earth diminishes its distance from the sun, and moves through less space, its momentum must then be increased; or, that if its momentum is increased, it will be required to move through less space, which is when it is in its perihelion. The waters in the southern hemisphere afford the means of this increased energy, and we know that the perihelion point corresponds at this time with the actual position of the waters. As the waters enlarge their bed, the perihelion point will progress northward, and hence the parallel of the perihelion, and the position of the way, become interchangeable cause and effect.

4. That the accumulation of the seas in that hemisphere, in which lies the direction of the perihelion perpendicular, is a cause and consequence of the increased mundane force, and is attended or caused by the oscillating momentum of the waters.

5. That the increments of quantity and momentum of the seas act by slow degrees on the land of the affected hemisphere, so as to produce space for their own accumulations, till in sufficient time the space occupied by the land is reduced in proportion to the accumulating spaces occupied by the seas.

In proof of this may be adduced, the acute angles of the southern continents, and the contrary forms of the northern ones. But as the perihelion has been nearly in the same parallel for 2000 years, so in that time no great changes have been perceivable. While the perihelion is passing from 29° of Scorpio to 2° of Aquarius, its declination varies only three degrees, and this requires a period of nearly four thousand years, on the received theory that the progression is uniform.

To understand this important theory, it is necessary to comprehend perfectly Sir R. Phillips's theory of the elliptical motions of the planets, which will be rendered plain by the following diagram:

If we suppose the sun and earth to turn in equilibrio round the fulcrum F, and that A represents the aphelion, or greater distance of the earth, and that P represents the perihelion distance, then it is evident, that for the earth and sun to move in equilibrio, while the earth is in those different distances, the energy of the earth must be increased at P, and comparatively diminished at A. This variable energy Sir Richard Phillips ascribes to the increased re-action of the waters in the southern hemisphere, the part of the earth opposed to the sun, when the earth is at P; and to the diminished re-action of the fixed northern continents, when these are opposed to the action of the sun, at the time the earth is at A. None of these phenomena, however, are explicable on the theory of universal gravitation.

6. That, as the seas encroach on the land in one hemisphere, they retire from the other, on the known fact of their constant quantity; but during the operation of the perihelion forces, they are also accumulated in volume sufficient to make new encroachments on the land, adding more and more to their momenta in each following year.

7. That, in 1821, the perihelion forces operate in maxima on the 31st of December, over the parallel of 23° 7′ south, that these forces are now moving northward at such a rate as that in the year 4719 they will arrive at a middle southern declination; in 6463 will act over the equator; in 8207 will advance to a middle northern declination, producing destructive effects on that hemisphere; and between the years 8207 and 15,184, will probably be the gradual means of covering the northern hemisphere with the sea, nearly as the southern hemisphere is covered at present.

8. That, in tracing the progression of these forces through former periods, it appears that they passed the equator to the southward about the year 4002 before Christ, producing, probably, such terrestrial phenomena as those described in the first chapter of Genesis; and that they reached a middle southern declination about the year 2258, producing, probably, such sensible effects in the tropical regions, as are described in the Mosaic and other accounts of the deluge.

9. That this motion of the perihelion forces over different parallels of terrestrial latitude, by producing an alternate preponderancy of seas in either hemisphere, sufficiently accounts for the marine strata, and for all the marine phenomena observed upon, or under, the surface of the land; the gradual operations of chemical agency being sufficient to account for the substantial changes in the bodies themselves.

10. That, if the frequent discovery of tropical remains in the latitude of Britain be considered as evidence that those remains were indigenous to these latitudes, the change of climate may be referred to the diminished angle formed by the planes of the equator and ecliptic, which now takes place at the rate of 52″ in a century, and of a degree in about 6900 years; and which would, if the motion were uniform, have been equal to 45° in seven revolutions of the perihelion point, or 149,000 years.

11. That this hypothesis of the extension of the tropics accounts for tribes of men being found within the Arctic Circle, in situations to which they never would have emigrated from the south; but where, being indigenous, and in utter ignorance of natural causes, they would continue to prefer the soil of their forefathers, in spite of gradual changes of climate, of which, in many generations, they would be insensible*.

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* For my own part, (says Sir R. Phillips,) I see no moral evil to deplore in the changes described. Nothing is effected abruptly; and men are gradually warned to seek new habitations. The notices are slow, but unerring; and animal races find fresh and renovated countries prepared for their subsistence, and abundantly fitted for their enjoyment, by these grand operations. These illustrations serve, at the same time, to explain phenomena which hitherto have baffled inquiry, and given countenance to numerous superstitions. They prove, that, when indefinite time is added to specific and atomic motion, matter is capable of assuming forms, which, if examined as momentary results, are inexplicable. In this case the specific aggregate motions are produced by the varied re-actions of the Earth, which produce actions of the moving waters on the external forms and surface of the land; while atomic motion, derived from the aggregate, produces changes in substances from heat, crystallization, trituration, saturation, and impregnation; from which result various strata, fossil remains, and different appearances in situations not usually adapted to their production. The several alternate strata of marine and land remains, observed by Cuvier, prove that the sea has covered the land at least many times; or, according to this theory, that the perihelion

The successive retreat of the waters is an indubitable fact. The waters covered the highest mountains. The Egyptian priests informed Herodotus, Plato, and others, that Egypt had been covered by waters which also occupied the deserts of Africa. Saussure and others have ascertained cavities in the calcareous bed bordering the Mediterranean, between Monaco and Vintimille, above 200 feet high, incontestably the work of the sea waters; and similar indications exist on the coast of Brittany, and several other countries. The retreat of the sea is perceptible in the Baltic: the lakes of Finland once joined its gulph to that of the White Sea, and all countries of the globe exhibit similar phenomena. When the ocean overwhelmed the level of Santa-Fe-de-Bogota, where are beds of coal and banks of shells, only some summits of the Cordilleras, Lupata, and Himayla mountains were above it. All other parts must necessarily have been under the waters, for no dikes exist high enough to keep up the sea at that level. Those who have said that the waters, by evaporation, could have passed into other globes, forget that even at a moderate height, the heat is null, and that the aqueous particles, suddenly condensed, return to the earth by their own weight. In our age, that body of waters is palpably accumulated in the southern hemisphere, which once covered high mountains between the tropics and in the northern hemisphere.

The horizontal position is not a fixed character in secondary lands; vertical beds, also, are found, and granite, in several places, arranged in layers. "The degradation of granite, its great inclination in strata,

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point has made many revolutions since the Earth has existed in its present form. Every one who views the interior of a country must be sensible that its swelling hills and valleys must have been produced by the action of water. In many inland situations, the cliffs still remain; and the accumulation of shells and fossil remains in particular spots prove that the tides for centuries wafted every thing moveable to certain points. The economy by which water forms land, even above its own level, is well understood by all who have witnessed what passes on the sea shore in situations where the sea is gradually retreating. In short, every fact supports the mechanical hypothesis, and tends to prove that all changes of matter, whether great or small, originate with great motions, which create small and specific ones, which serve as the proximate causes of local and particular phenomena.

and their great thickness, cause naturalists to mistake their structure. But, by studying the granite, where it is not divided into fragments, it is obvious that Nature produces inclined and vertical strata, as regularly as horizontal; and, as in calcareous mountains, are strata 60 feet thick, certainly granite was originally formed in layers, as much as marble and slate." *Saussure.*—"The entire mass of continents is composed of strata, similar to the regular layers of stones in houses. All are broken; great masses being wanting, where they must have been formerly; and those now visible, are partially overturned. The actual horizontality is not necessary to admit the primitive stratification; for vertical strata contain parts of marine animals, which must have been formed in a horizontal position." *Delve.* Cuvier observed 12 periods in the superposition of gypsum, at Montmartre. In one place, are scarcely any vestiges of marine animals; and, in another centre, mountains are composed of their wrecks. What intervals between these extremes! what successive deposits have been effected! what progressions in the existences!

How can it be, (says Eratosthenes, cited by Strabo), that in the midst of the continent, at 2000 or even 3000 stadia from the sea, we find in many places marshes of sea water, (salt lakes) and quantities of shells, of either oysters or muscles? Near the temple of Ammon, and on all the road 3000 stadia long, we see heaps of oyster-shells and salt; also bubbling springs of sea water; and besides, fragments of vessels, which some say were thrown out of the bottom of an abyss, and figures of dolphins placed on small columns, with this inscription, Cyreneian Theores. Except these monuments of art, the desert of Lybia is now as Eratosthenes described it; traces of the sojourning of the seas exist in all Sahara. Plato mentions the disaster of the Atlantis. Was it a great island, or a continent? What catastrophe could occasion its disappearance? As to Sahara, it indubitably was covered by the waters of a sea joining the Mediterranean, and extended to the last cataracts of the Nile. The ocean's gradual retirement to the southern hemisphere left this space dry. No alluvial land was established, and vegetation could not fix, so that nothing but an arid and sandy soil was left, except Egypt fertilized by the Nile; and Soudan watered by the Joliba. This was when the perihelion point passed the equator.

Similar events occurred, though earlier, in the high plains of South America, (Los Llanos, Campo de Giguantes, &c.) and of central Asia, (as the desert of Gobi and Shamo). As the level of the seas lowered, these happened to the deserts of Arabia and Persia, the borders of the Caspian, &c. The continents were not then above the level of the waters, but only the masses of the mountains, as so many islands, similar to the Indian Archipelago; the great rivers were mere currents, and the currents brooks. The Mediterranean joined the Red Sea, and the Caspian. The Euxine extended into the north of Asia, fell into the Frozen Sea by the valley of the Obi, and the Lakes of Finland. The Oural Chain was an island, and so was each of the mountains. Of this uncertain epoch, the Egyptian priests informed Herodotus, that in the time of Menes all Egypt was a marsh, except Thebes; and there was nothing of the land beyond Lake Mœris, seven days journey, ascending the river.

Strato states, that formerly the Euxine had no issue on the side of Byzantium; but the rivers, which disgorge into that sea, forcing the obstacle, opened a passage. The waters fell into the Propontis, and thence into the Hellespont; in like manner, the Mediterranean, filled by rivers, burst the isthmus which closed the Straits of the Pillars; and flowing off by the new canal, may have left dry what was formerly shallows. This event caused the inundation of Samothracia, mentioned by Diodorus of Sicily; and the waters, stretching from Asia Minor to Greece, perhaps divided the isles of the Archipelago.

All ancient traditions relate similar fluctuations. In Chaldea, the deluge of Xixuthrus; in Syria, of Hierapolis; in Greece, of Ogyges and Deucalion; in Egypt, of Prometheus: the Chinese, Mexicans, Greenlanders, &c. have had their deluge. In several parts are now high plains, incontestably lakes. Subner discovered several in the Hircanian mountains, the most western branch of the Krapacks. Bohemia, Cachemire, and many other countries, give evident proofs.

Before these successive drains of the lakes, and while the ocean bathed all the base of the mountains, volcanos appeared at their summits; because, each mass being an island, every thing happened like as at Java, Sumatra, and the Philippines. Upper Egypt and Tartary had volcanos; also, the branches of the Pyrenees, the Cevennes, in the Alps, the mountains of Auvergne, the shores of the Rhine, and wherever we find traces thereof. All these volcanos then exhibited analogous phenomena. Currents of lava covered or furrowed the sides of mountains; ashes and scoriæ, mixing with rocks, raised factitious hills; muddy eruptions impeded and changed the course of the waters, earthquakes opened abysses, sunk some lands, and raised others.

In 1782, Formosa was twice traversed by the waters raised by the explosion of a submarine volcano. In 1740 the sea ascended far beyond, and swallowed up the port of Callao. In 1737, after a great eruption of the volcanos of Awatcha in Kamschatka, the ocean, twice driven from its limits, returned and rose 200 feet high. Precisely at this height Dolomieu found shells on the sides of Etna. Hence the environs of extinct volcanos present many singularities. The epoch of their eruptions is very remote, as they ceased when the ocean had removed from the base of the mountains, and was replaced by the alluvial lands.

During this period, extraordinary fires may have happened, by the inflammation of a mass of pyrites and bitumen, or even from great drought. Such a fact is recorded as happening in Spain, in the seventeenth century. It did not rain in the Sierra Morena for 14 years, which produced such an extreme dryness, that all the springs dried up, the forest took fire, the earth opened, and frightful crevices and rents remain visible, to prove this event.

An abundance of rain would cause the rapid degradation of the mountains; the level of Tartary in Asia, is only the base of a mountain of an immense height, and terminated in several pyramids, lost in the void of the atmosphere.

The surrounding plains are entirely the wrecks of this colossal mass. The other mountains were much higher. The atmosphere supporting itself much higher, the temperature was mild, where now are extensive glaciers. Instead of great plains were valleys, as in Switzerland, Peru, &c. The continual rains swelled the torrents which hollowed out the earth, and accumulated heaps at the foot of the mountains.

These united causes changed the order of superposition of the strata. The rocks of different formations intermingled, sinkings in the oceanic lands occurred by desiccation, mountains rolled down, from commotions, or by running waters, hills rose up, and the earth's surface presented those irregularities met with at every step.

Volcanic eruptions produced inequalities, but did not alter the aspect of the country; lakes formed an issue, land rolled down, others rose; but these changes, strictly local, had narrow limits, and were without sensible influence.

We have authentic accounts of the rolling down of some lands, and even entire mountains. Thus the fall of the mountain Diableret, in the Valais, in 1714, covered a square league with its ruins. In 1618 a similar event happened and destroyed Pleurs Grisons. The ruins of Velleia, a Roman colony, seven leagues from Piacenza, now attest the fall of two mountains from the mass of the Apennines. The borders of the Alps and Pyrenees, and all masses of mountains, indicate similar accidents; in general caused by the running waters detaching the earthy and not very tenacious strata, which support the mountainous mass. Donati describes a mountain fall he witnessed in July, 1751, on the side of Sallanches in Savoy. "A great part of the mountain below that which rolled down, was composed of earth and stones, not arranged in quarries or beds, but confusedly heaped up. Thence I ascertained that similar falls had happened in the same mountain, and thereby left without support, and leaning considerably forward, the great rock which fell this year, composed of horizontal beds, the two of slate or foliated stone, brittle, and of little consistence: the two upper beds of a marble like that of Porto-Venere, but full of transversal rents; slates with vertical but severed leaves, wholly composed the fifth bed, which formed the upper plain, whereon were three lakes, whose waters penetrated, continually separated the rents of the beds, and decomposed their supports. The effect was increased by the snow, which that year fell in Savoy, more abundantly than in the memory of man. These united waters occasioned the fall of three millions of cubic toises of rock, a volume alone sufficient to form a great mountain."

Sinkings are not less common in certain cavernous districts; and at every step, on calcareous land, are obvious traces. All the secondary mountains exhibit interrupted beds and crevices, caused by accidents which since their formation, have not discontinued, but are now more scarce, and confined to changes of little importance.

The atmosphere has a penetrating and corrosive power, less sensible, but infinitely more powerful, than that of the ocean. Granite, which resists the action of water, is decomposed by air; the metals are oxydized, and fall into powder; stones, salts, and all solid bodies, effloresce. These facts have an important rank in the economy of the globe. The granitic peaks, and the rounded summits of the calcareous mountains, are corroded, incided, and reduced. The air seizes their particles, dissolves, and becomes saturated therewith; but immediately, their weight exceeding that of the fluid in which they move, they return again to the earth's surface. The phenomenon of vaporization accumulates liquids in the air, which fall again in rain, that furrows, and completely deteriorates the rocks. When impeded by causeways, or dikes, the water spreads in sheets; but, the obstacles being surmounted, causes the drainage and desiccation of lakes, &c. Earthy parts of rocks are shaken out; the blocks attacked at their base, and without support, incline, slip, and rushing down impetuously, cover immense tracts with their ruins, which are borne along to the sea shore. The waters, ever in motion, hollow out the borders of their basin; but the accumulations of the rivers extend the terrestrial surface; and, while new gulfs and new bays are opened there, here, marshy plains, and humid savannahs, form and encroach on the domain of the ocean.

Proofs of this appear on encompassing the geographical knowledge of the ancients and moderns. The Delta of the Nile is more advanced than in the time of Herodotus. Aigues-Mortes, and Frejus, are no longer on the shore of the Mediterranean; the whole of Guiana is the accumulations of the Amazon, Oronoko, and other rivers east of the Cordilleras. The Mississippi every day enlarges the fertile soil of Louisiana; and every country of the globe, watered by great streams, is subject to similar changes.

In Britain, the Chronicles of Eri record the period when the Scilly Islands were separated from Cornwall. Large tracts in Kent were swallowed by the sea, just before the Norman Conquest. Large parishes in Sussex have been absorbed within a century, and on the other hand the sea has, within a few years, retreated from the eastern coast, so as to render once flourishing ports useless.

In addition to these general causes, Count Chaptal has written a beautiful essay on the details of these changes, which we present entire for the gratification of the reader:

When, says he, we contemplate the globe in populous districts, our attention is chiefly directed to the agency of man, and those energies of social life which produce, modify, and change the prospect around us. But when we enter the wild and romantic scene of a mountainous country, we are everywhere struck with the vestiges of operations carried on by the powers of nature, through a long series of ages, and upon a scale prodigiously greater than any to which the works of man can be extended. We meditate on the surrounding scene with an emotion resembling that produced by the view of a pile of ruins long since gone to decay. We endeavour to investigate what may have been the original state of the pile; and, for want of information, our conclusions are for the most part little better founded than those of an amusing reverie.

It appears, from a great variety of observations, that the internal part of the globe consists of stone called *granite*. It is this which shows itself as the limit of all the excavations made on the surface of our planet, either by natural causes or the art of man.

Water, collected in the cavity of the ocean, is carried by the winds to the tops of the most elevated mountains, where it is precipitated in rain, and forms torrents, which return with various degrees of rapidity into the common reservoir.

Such an uninterrupted motion and fall must gradually attenuate and wear away the hardest rocks, and carry their pulverulent parts to distances more or less considerable. The action of the air, and the varying temperatures of the atmosphere, facilitate the attenuation and the destruction of these rocks. Heat dries their surface, and renders it more accessible, and more penetrable to the water which succeeds; cold divides them, by freezing the water which has entered into their texture; the air itself affords the *carbonic acid*, which attacks the *limestone*, and causes it to effloresce; the oxygen air unites to the iron, and oxydes it; insomuch that this concurrence of causes favours the disunion of principles; and consequently the action of water, which clears the surface, carries away the products of decomposition, and makes preparation for a succeeding process of the same nature.

The first effect of the rain is therefore to depress the mountains. But the stones which compose them must resist in proportion to their hardness; and we ought not to be surprised, when we observe peaks that have braved the destructive action of time, and still remain to attest the primitive level of the mountains which have disappeared. The primitive rocks, alike inaccessible to the injury of ages as to the animated beings which cover less elevated mountains with their remains, may be considered as the source or origin of rivers or streams. The water which falls on their summits, flows down in torrents by their lateral surfaces. In its course it wears away the soil upon which it incessantly acts. It hollows out a bed of a depth proportioned to the rapidity of its course, the quantity of its waters, and the hardness of the rock over which it flows; at the same time that it carries along with it portions and fragments of such stones as it loosens in its course.

These stones, rolled along by the water, must strike together, and break off their projecting angles; a process that must quickly have afforded those rounded flints, which form the pebbles of rivers, and which are found to diminish in size, in proportion to the distance from the mountain which affords them.

The pulverulent remains of mountains, or the powder which results from the rounding of these flints, are carried along with greater facility than the flints themselves: they float for a long time in the water, the transparency of which they impair: and when these said waters are less agitated, and their course becomes slackened, they are deposited in a fine and light paste, forming beds more or less thick, and of the same nature as that of the rocks to which they owe their origin. These strata gradually become drier by the agglutination of their principles; they become consistent, acquire hardness, and form siliceous clay, silex, petrosilex, and all the numerous class of pebbles, which are found dispersed in strata, or in banks in the ancient beds of rivers.

The mud is much more frequently deposited in the interstices left between the rounded flints themselves, which intervals it fills, and there forms a true cement, that becomes hard, and constitutes the compound stones known by the name of pudding-stones and grit-stones: for these two kinds of stone do not appear to me to differ but in the coarseness of the grain which forms them, and the cement which connects them together.

We sometimes observe the granite spontaneously decomposed. The texture of the stones which form it has been destroyed; the principles, or component parts, are disunited and separated, and they are gradually carried away by the waters.

Most siliceous stones, formed by the deposition of running waters, and hardened by the lapse of time, are easily subjected to a second decomposition. *Iron* is the principal agent of these secondary alterations; and its oxydation, determined by air or water, produces a disunion of principles. Nature may be observed in this process, by an attentive examination of such alterations as *gun-flints*, *variolites*, *porphyries*, *jaspers*, and the like, are subjected to.

The decomposition of flints, chalcedonies, agates, and generally all stones of this kind, which possess a certain degree of transparency, are referable to the volatilization of the water, which forms one of their principles, and is the cause of their transparency. These stones may be considered as commencements of crystallization: and when the water is dissipated, they effervesce after the manner of certain neutral salts. Hence it arises, that the decomposition is announced by opacity, a white colour, loss of consistence and hardness; and terminates by forming a very attenuated powder, sometimes of extreme whiteness. It is this decomposition, more particularly, which forms *clays*.

There are flints, the alterations of which form effervescent *marls*. These do not appear to be of the nature of primitive rocks: they have the same origin as the calcareous stones, from which they differ only in consequence of a very considerable proportion of clay. The stones which we so abundantly find of this nature around us, among calcareous decompositions, may be considered as of this kind.

Water filtrating through mountains of primitive rock frequently carries along with it very minutely divided particles of quartz; and proceeds to form, by deposition, *stalactites*, *agates*, *rock crystal*, &c. These quartzose stalactites, differently coloured, are of a formation considerably analogous to that of calcareous alabasters; and we perceive no other difference between them than that of their constituent parts.

Thus far we have exhibited, in a few words, the principal changes, and various modifications, to which the primitive rocks have been subjected. We have not observed either germination or life: and the metals, sulphur, and bitumens, have not hitherto presented themselves to our observation. Their formation appears to be posterior to the existence of this primitive globe; and the alternations and decompositions, which now remain to be inquired into, appear to be produced by the class of living or organized beings.

On the one hand we behold the numerous class of shell animals, which cause the stony mass of our globe to increase by their remains. The spoils of these creatures, long agitated and driven about by the waves, and more or less altered by collision, form those strata and banks of *limestone* in which we very often perceive impressions of those shells to which they owe their origin.

On the other hand we observe a numerous quantity of vegetables, that grow and perish in the sea; and these plants likewise, deposited and heaped together by the currents, form strata, which are decomposed, lose their organization, and leave all the principles of the vegetable confounded with the earthy principle. It is to this source that the origin of *pit-coal*, and secondary *schistus*, is usually attributed; and this theory is established on the existence of the texture of decomposed vegetables very usually seen in schisti and coal, and likewise on the presence of shells and fish in most of these products.

The formation of pyrites ought to be attributed to the decomposition of vegetables: it exists in greater or less abundance in all schisti and coal. A wooden shovel was found buried in the depositions of a river, converted into jet and pyrites. The decomposition of animal substances may be added to this cause: and it appears to be a confirmation of these ideas, that we find many shells passed to the state of pyrites.

Not only the marine vegetables form considerable strata by their decomposition; but the remains of those that grow on the surface of the globe ought to be considered among the causes or agents, which concur in producing changes upon that surface.

The *calcareous mountains* are constantly placed upon the surface of the primitive mountains; and though a few solitary observations present a contrary order, we ought to consider this inversion and derangement as produced by shocks, which have changed the primitive deposition. It must be observed also, that the disorder is sometimes merely apparent; and that some naturalists of little information have described calcareous mountains as inclining beneath the granite, because this last pierces, as it were, through the envelope, rises to a greater height, and leaves at its feet, almost beneath it, the calcareous remains deposited at its base. Sometimes even the *limestone* fills to a very great depth the crevices or clefts formed in the granite. It likewise happens frequently enough, that such waters as are loaded with the remains of the primitive granite heap them together, and form secondary granites, which may exist above the calcareous stone.

The calcareous mountains are decomposed by the combined action of air and water; and this fluid, which does not possess the property of holding it in solution, soon deposits it in the form of *gurhs*, *alabasters*, *stalactites*, &c. Spars owe their formation to no other cause. Their crystallization is posterior to the origin of calcareous mountains.

Waters wear down and carry away calcareous mountains with greater ease than the primitive mountains: their remains being very light are rolled along, and more or less worn. The fragments of these rocks are sometimes connected by a gluten or cement of the same nature; from which process *calcareous grit* and *breccias* arise. These calcareous remains formerly deposited themselves upon the quartzose sand; and the union of primitive matter and secondary products gives rise to a rock of a mixed nature, which is common in many places.

The mountains of *secondary schistus* frequently exhibit to us a pure mixture of earthy principles, without the smallest vestige of bitumen. These rocks afford, by analysis, silex, alumine, magnesia, carbonat of lime, and iron; principles which are more or less united, and consequently accessible in various degrees to the action of such agents as destroy the rocks hitherto treated of.

These same principles, when disunited, and carried away by waters, give rise to a great part of the stones comprised in the *magnesian genus*. The same elements, worn down by the waters, and deposited under circumstances proper to facilitate crystallization, form the *schorls, tourmaline, garnets*, &c.

It frequently happens, that the secondary schisti are interspersed with *pyrites;* and in this case, the simple contact of air and water facilitates their decompositions. Sulphuric acid is thus formed, which combines with the various constituent principles of the stone; whence result the sulphates of iron, of magnesia, of alumine, confounded together. The pyritous schisti are frequently impregnated with bitumen, and the proportions constitute the various qualities of *pit-coal.*

It appears to Count Chaptal, that we may lay it down as an incontestable principle, that the pyrites is abundant in proportion as the bituminous principle is more scarce. Hence it arises, that coals of a bad quality are the most sulphureous, and destroy metallic vessels by converting them into pyrites. The focus of volcanos appears to be formed by a schistus of this nature; and in the analyses of the stony matters which are ejected, we find the same principles as those which constitute the schistus. We ought not therefore to be much surprised at finding schorls among volcanic products; and still less at observing, that subterranean fires throw sulphuric salts, sulphur, and other analogous product, out of the entrails of the earth.

The remains of terrestrial vegetables exhibit a mixture of primitive earths more or less covered by iron; we may therefore consider these as a matrix, in which the seeds of all stony combinations are dispersed. The earthy principles assort themselves according to the laws of their affinities; and form crystals of spar, of plaster, and even the rock crystals, according to all appearance; for we find ochreous earths in which these crystals are abundantly dispersed; we see them formed almost under our eyes. We may frequently observe indurated ochres full of these crystals, terminating in two pyramids.

The ochreous earths appear to deserve the greatest attention of naturalists. They constitute one of the most fertile means of action that nature employs; and it is even in earths nearly similar to these, that she elaborates the diamond, in the kingdoms of Golconda and Visapour.

The spoils of animals, which live on the surface of the globe, are entitled to some consideration among the number of causes, which we assign to explain the various changes our planets is subject to. We find bones in a state of considerable preservation in certain places; we can even frequently enough distinguish the species of the animals to which they have belonged. From indications of this sort it is, that some writers have endeavoured to explain the disappearance of certain species; and thence to draw the conclusion, either that our planet is perceptibly cooled, or that a sensible change has taken place in the position of the axis of the earth.

LECTURE XXVI.

VOLCANOS.

——— The fluid lake that works below,
Bitumen, sulphur, salt, and iron scum,
Heaves up its boiling tide. The lab'ring mount
Is torn with agonizing throes. At once,
Forth from its side disparted, blazing pours
A mighty river; burning in prone waves,
That glimmer'd through the night to yonder plain.
Divided there, a hundred torrents stream,
Each ploughing up its bed, roll dreadful on,
Resistless. Villages, and woods, and rocks,
Fall flat before their sweep. The region round,
Where myrtle walks and groves of golden fruit
Rose fair; where harvest waved in all its pride;
And where the vineyard spread its purple store,
Maturing into nectar; now despoiled
Of herb, leaf, fruit, and flower, from end to end
Lies buried under fire, a glowing sea. MALLET.

THE most remarkable changes which have taken place in the form and constitution of the earth, since the deluge, have probably been produced by subterraneous fires; for it is to their agency that philosophers ascribe volcanos and earthquakes; those tremendous instruments of nature, by which she converts plains into mountains, the ocean into islands, and dry land into stagnant pools:

With loud displosion, to the starry frame,
Shoots fiery globes, and furious floods of flame:
Now from her bellowing caverns burst away
Vast piles of melted rocks in open day.
Her shatter'd entrails wide the mountain throws,
And deep as hell her flaming centre glows. WARTON.

When these fires were first kindled; by what sort of fuel they are still maintained; at what depths below the surface of the earth they are placed; whether they have a mutual communication; of what dimensions they consist; and how long they may continue, are questions which do not admit an easy decision. But though it will ever be impossible for us to search far into the bowels of the earth, or to imitate, in an extensive degree, the great operations which are constantly carrying on beneath its surface, yet it affords a curious mind no mean degree of satisfaction to be able, by obvious experiments, to form some reasonable conjectures concerning them.

Dr. Watson, in his *Chemical Essays*, says, " Mr. Lemery, as far as I have been able to learn, was the first person who illustrated, by actual experiment, the origin of subterraneous fires. He mixed twenty-five pounds of powdered sulphur with an equal weight of iron filings; and having kneaded the mixture together, by means of a little water, into the consistence of a paste, he put it into an iron pot, covered it with a cloth, and buried the whole a foot under ground. In about eight or nine hours time the earth swelled, grew warm, and cracked: hot sulphureous vapours were perceived; a flame, which dilated the cracks, was observed; the superincumbent earth was covered with a yellow and black powder: in short, a subterraneous fire, producing a volcano in miniature, was spontaneously lighted up from the reciprocal actions of sulphur, iron, and water. That part of this experiment which relates to the production of fire, by the fermentation of iron filings and sulphur when made into a paste, has been frequently repeated since the time of Mr. Lemery.

" That heat and fire should be generated from the spontaneous actions of minerals upon each other, is a phenomenon by no means singular in nature, how difficult soever it may be to account for it. The heat of putrescent dunghills, of the fermenting juices of vegetables, and, above all, the spontaneous firing of hay not properly dried, are obvious proofs that vegetables possess this property as well as minerals. In both vegetables and minerals, a definite quantity of moisture is requisite to enable them to commence that intestine motion of their parts, which is necessary for the production of fire. Iron and sulphur would remain mixed together for ages without taking fire, if they were either kept perfectly free from moisture, or drenched with too much water; and vegetables, in like manner, which are quite dry, or exceedingly wet, are incapable of taking fire while they continue in that state.

" But though it is certain, from the experiment, that mixtures of iron and sulphur, when moistened with a proper quantity of water, will spontaneously take fire; yet the origin of subterraneous fires cannot, with any degree of probability, be referred to the same principle, unless it can be shown that nature has combined together, in large quantities, iron and sulphur, and distributed the composition through various internal parts of the earth.

" There is, perhaps, no mineral more commonly met with than that which is composed of iron and sulphur. It is found not only upon the face of the earth, but at the greatest depths below it, to which mines have been hitherto driven, and in all parts of the world. This mineral is called, in some parts of England, copperas-stone; in others, brazil; in others, brass-lumps; in others, rust-balls; in others, horse-gold; in others, marcasite. The scientific name is *pyrites*,—fiery: a denomination expressive enough of the property which this mineral has of striking fire with steel, and of spontaneously taking fire, when laid in heaps, and moistened with water. So much of this sort of the pyrites

The Great Crater of Etna in 1820.

is dug up together with the coal, at Whitehaven, Newcastle, and other places, that people are employed to pick it out from among the coal, lest it should vitiate its quality, and render it less saleable. The pieces of the pyrites, which are separated from the coal, are not thrown aside as useless, but laid in heaps, for a purpose to be mentioned hereafter; and these heaps, not many years since, took fire, both at Whitehaven and in the neighbourhood of Halifax. The same accident was observed above a hundred years ago, at Puddle Wharf, in London, where heaps of coal, which contained much of this pyrites, took fire.

"Though Lemery was the first person who, by artificial mixtures of sulphur and iron, produced fire, yet that natural mixtures of these substances would spontaneously take fire, was known before he made his experiment. In 1664, a man at Ealand, in Yorkshire, had piled up in a barn many cart-loads of the pyrites, or brass-lumps, as they were called by the colliers, for some secret purposes of his own: the roof of the barn happening to be bad, the pyrites were wetted by the rain; in this state they began to smoke, and presently took fire, and burned like red-hot coal.

"In 1751, the cliffs near Charmouth, in Dorsetshire, took fire, in consequence of a heavy fall of rain, after a hot and dry season; and they continued, at intervals, to emit flame for several years.—These cliffs consist of a dark-coloured bituminous loam, in which are imbedded large quantities of different kinds of the pyrites. The same kind of flame has been frequently observed in the Cornish mines, and this mineral fire sometimes leads to the discovery of a mine; but wherever it is found to exist, the iron pyrites is generally discovered near it."

Volcanos generally exist in the vicinity of the sea or large lakes, and also break out from unfathomable depths below the sea, and form new islands with the melted lava and stones which they eject. When a volcano breaks out in a new situation, it forms a vast rent or fissure, through which lava and stones are thrown out, that soon choke up the passage, and confine the eruption to one or more openings, round which a conical mountain is formed, the open part of which is called the crater.

The indications of an approaching eruption are, an increase of smoke from the summit, which sometimes rises to a vast height, branching in the form of a pine-tree. Tremendous explosions, like the firing of artillery, commence after the increase of smoke, and are succeeded by red-coloured flames and showers of stones; at length the lava flows out from the top of the crater, or breaks through the sides of the mountain, and covers the neighbouring plains with melted matter, which, becoming consolidated, forms a stony mass, often not less than some hundred square miles in extent, and several yards in thickness. The eruption has been known to continue several months. The quantity of volcanic powder, called ashes, thrown out, is inconceivably great.

During one eruption of Ætna, a space of 150 miles in circuit was covered with a stratum of sand twelve feet thick. When the lava flows freely, the earthquakes and explosions become less violent, which proves that they were occasioned by the confinement of the erupted matter, both gaseous and solid. The smoke and vapour of volcanos are highly electrical. The long period of repose which sometimes takes place between two eruptions of the same volcano, is particularly remarkable.

In the volcanic land series of points may be traced, seemingly connected. The whole granitic chain, which borders the Pacific, is crowned by volcanos; beginning at the straits of Maghellan, with the Andes, which in Chili has fourteen burning craters. Those of Peru are most numerous and terrible, as are those of the isthmus of Mexico, and California. The littoral chain to Alashka, offers several volcanos, some in activity. Others are found in that semicircular chain of islands between the continents, terminating near Kamschatka, in which peninsula are five active volcanos, besides many extinct craters, which reach to Daouria.

South of Kamschatka, the ignivomous chain traces the Kourvilla isles, Jesso, and Japan; a series of volcanic islets joins on to the Marianne isles, which have nine active volcanos; and thence through Polynesia. Another branch runs south, by Lieou, Kiou, Formosa, Philippines, Indian Archipelago, and Australasia to New Zealand, where remain unequivocal signs of subterranean fires.

Several ramifications go off to the Indian Sea. In the Mauritius is an active volcano; the Isles of France and Madagascar, St. Paul, and Amsterdam, are covered with leaves, ashes, and scoriæ; the mineral waters and confused mountains of the Cape of Good Hope, indicate subterraneous fires; the Gebel-Tar, is an extinct crater, at the entrance of the Red Sea, between the ancient volcanos of Upper Egypt and Syria, which join those of America, and Caucasus, and the isles of the Archipelago, whose fires burst forth occasionally, in the caverns of Lemnos, Milo, and Santorin. The Ionian Isles, in the Adriatic, are volcanic; and ignivomous mountains are on the coast.

Sicily has its Etna, Naples its Vesuvius, and Strombolo, in the Islands of Lipari.

All Italy offers vestiges of ancient volcanos, by the Apennines; the coasts of Provence, where are the extinct craters of Olioules, and Evenos; another on the Alps of Dauphiny; and in Spain are the solfataras, leaves, and puzzolanas, in the environs of Burgos. All Upper Germany, between the Alps and Krapacks, indicates ancient volcanos; especially in Bohemia, Hesse, Lusatia, Hungary, Silesia, &c. Mount Atlas rests on volcanic ground, and also the islands of St. Helena, and Assumption, composed of leaves and ashes; the Cape Verd Islands, of which, Fuego always throws out flames; the Canaries, whose Peak of Teneriffe is a higher volcano than Etna; the Azores, incessantly disordered by submarine fires; the British Isles, with Ireland, famed for its Giant's Causeway; the Hebrides, the Feroe Isles, and finally, Iceland, which terminates this long chain by Mount Hecla, a focus more active than Vesuvius. On the coast of America, Guadeloupe, Dominica, Trinidad, &c. have active craters.

In this great number of volcanos only those are ignivomous situated near the sea; the others were so only when the ocean was not yet fixed in its actual basin. These ancient volcanos are not in a greater quantity, on account of the unequal periods of their existence. Their fires ceased as the ocean no longer bathed the sides of the craters; and others were formed which disappeared from the same causes. Thus the extinct volcanos indicate the successive retreat of the waters, and of the limits of their basin. But such observations are very incomplete, and even in the centre of Europe, doubts remain on the volcanic nature of some lands. The absence of volcanos in the north is consequent on these countries being the last abandoned by the sea, and too low for a focus to subterraneous fires. By comparing localities, the neighbourhood of the sea, and the elevation of the land, are necessary circumstances for this phenomena. Hence volcanos are so terrible in the chain of the Cordilleras, so frequent in high islands; and so rare, or rather unknown, on low coasts.

It is supposed by several authors, that the fires of Etna communicate with those of Vesuvius, whose focus extends through part of Italy, below the Solfatara. It is probable that such subterraneous communications exist; and Humboldt says the same takes place in the great volcanos of Peru. Speaking of the valley of Quito, he says: "probably the whole high part of the province is only one volcano: what are called the mountains of Cotopaxi and Pichincha are only little summits, whose craters form different vents, all ending in the same hollow." "From the enclosure of the crater of Pichincha there rise, as if darting from the abyss, three peaks; three rocks, not covered with snow, because the vapours the mouth of the volcano exhales melt them constantly. To examine the bottom of the crater, we lay down flat, and it is impossible for the imagination to figure any thing more dismal, melancholy, and frightful, than what we then beheld. The mouth of the volcano forms a circular hole, nearly a league in circumference, its perpendicular edges covered with snow; the interior quite black, but the abyss so immense, that we could distinguish the tops of several mountains in it; their summits seemed to be 2 or 300 toises below us; judge then where their base must be. I have no doubt that the bottom of the crater is on a level with the town of Quito." The phenomena of Pichincha, however, and of the other volcanos of Peru, only differ from those of Vesuvius, in the flow of lava being more scarce. Cavanilles relates, that in 1797, " the summits of the mountains rolled down, and from their split sides came out such an immense mass of fœtid water, that in a little time it filled valleys 1000 feet broad and 600 deep, and in a few days condensing by desiccation into an earthy and very hard crust, it intercepted the course of rivers, and made them flow backwards for 87 days.

Muddy eruptions likewise are occasioned merely by the superabundance of water, which soaks the matters in proportion as they enter into combustion; but this fact, very rare in ordinary volcanos, is habitual in salses. Dolomien first made them known by his description of the muddy volcanos of Macalouba in Sicily: " The soil of the country is calcareous; covered with mountains and hillocks of argil, some with a gypseous nucleus. One mountain (argillaceous) with a circular base, represents imperfectly a truncated cone, perhaps 150 feet high, and terminated by a plain, a little convex, half a mile round. On this summit are many truncated cones, the largest two feet and a half high, the smallest only a few lines. All have on their summits little craters, in the form of funnels, proportioned to their mass. The ground on which they rest is a grey dried clay, over a vast and immense abyss of mud, in which there is the greatest risk of being swallowed up. The interior of each little crater is always moist; from the bottom of the funnel rises every moment a grey liquid clay with a convex surface; this bubble, bursting with a noise, throws the clay out of the crater, and it flows like lava on the sides of the hillock; the intermittence is two or three minutes."

Spallanzani found similar volcanos in the hills of Modena and Reggio; Pallas, in the Crimea; Dolomien attributes this phenomenon to the sulphuric acid in the clay disengaging the carbonic acid of the calcareous base of the argillaceous mountain. But on comparing the salses, with the ordinary volcanos, whose ejections are principally dry and very solid matters, to the burning tracts, like the Solfatara, the Pietra-Mala, and several regions in Italy, whence fluids are continually disengaged, it is obvious that these three phenomena have an identical cause, producing different effects, because of the inequality of action in the three principal agents. Thus, when the solids predominate, as in the great volcanos, whose focus is in homogeneous and primitive mass, the solids decompose the water and disengage the fluids, so that the residuum can be only dry substances diversely combined and altered, as lavas, volcanic glass, ashes, scoriæ, &c. If the water exceed, the eruption produces torrents of mud, as in the salses and the muddy ejections; and if the fluids superabound, we see only heat and light disengaged, as in the Solfataras, &c. &c. Yet the atmospheric fluids, the oceanic liquids, and the terrene solids, collecting in one focus, sometimes meet in unequal portions, and mutually influence each other; hence a volcano throws out a Nile d'acqua, or columns of fire and smoke.

On establishing the fermentation of volcanic matters, the efforts of the agents in the focus are communicated around, and produce a trepidation seldom extending far, and violent, according to the cavernous nature of the ground. The fluids restored by the re-action on the bases held in solution, can only disengage themselves from the crater by the eruption of the compressing matters. Part of these fluids passes through the mass of the ground, especially when schistous, as in the primitive formations; or when it has voids, as in the secondary. Here the commotion is felt, and produces sinkings when the currents of air violently shake the beds they traverse.

Several parts of Italy exhibit traces of these sinkings. In Jamaica, during the earthquake of 1692, some portions of the island fell in, abysses opened, lakes took the place of mountains, and most of the high grounds sunk.

When the fluids are too much resisted horizontally, as in the granite land, their expansibility then acts from below upwards, and enormous masses are raised.

Such risings have been often observed, but none more remarkable than that in 1759, in the high plain of Mexico. A mountain, 1494 feet high, rose smoking from the bowels of the earth, and is yet pierced with crevices, whence inflammable gases incessantly exhale. Its summit is a crater always on fire, in which Humboldt descended, through fragile lavas, a perpendicular depth of 258 feet. Monte-Nuovo, near Vesuvius, was thus formed.

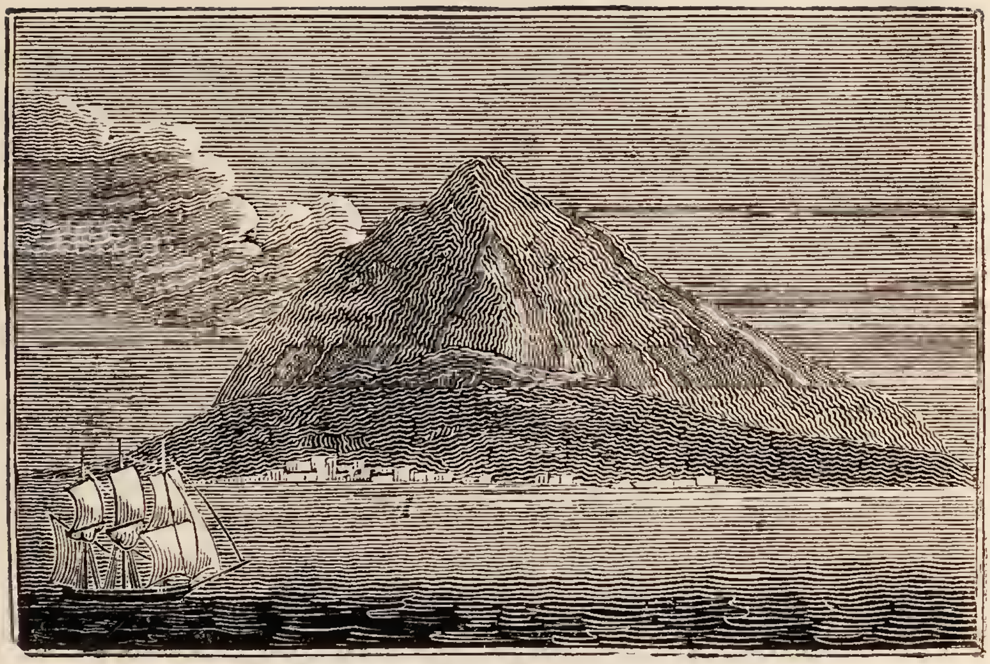
The appearance of new islands is owing to similar causes; for the sub-marine volcanos, in some latitudes, resemble ordinary ones. Those best known are the Archipelago and Azores. Many curious events have happened round Santorin, whose port occupies the bottom of a crater as large as that of Pichincha. Its eruptions have raised several isles from the waves; the

Hiera (Migali Kammani) is the most ancient, and has enlarged successively. Others occurred in A. D. 19, 46, and 60. In 1508, Theresia was divided, and in 1707, and 1712, continual changes produced a new island two leagues round, while another, which appeared in 1553, sunk with a part of Thera near it. Delos and several other islands have similar origin ; at the Azores similar phenomena yet happen. In Iceland the eruptions of Hecla have been followed by the appearance of new islands. The Mauritius, and others in the Indian Ocean, are supposed to have been produced by similar risings. In short, these sort of changes are often produced around a volcanic focus ; and earthquakes are frequent in some places, as at Manilla, which island is always oscillating.

This kind of earthquake being dependent on volcanic phenomena, cannot extend far; a few only cause brisk shocks, or local changes : a volcanic country may be thus agitated, yet it is seldom perceived a few leagues off. A person remembers in Elba no commotion in 1794, during the eruption of Vesuvius which destroyed La Torre. Besides, such changes, though continual in those countries, have no consequences, and the ground always presents nearly the same aspect. Greece remains such as Homer, Aristotle, Herodotus, Strabo, &c. described it; and on Etna are found the spots described by Diodorus of Sicily, and Solinus; the Italy of Virgil and Pliny is that of our days : perhaps in Peru only, where all is colossal, are exceptions found. According to Humboldt the great earthquake, Feb. 4, 1797, in which 40,000 individuals perished, changed the temperature of the high plain of Quito ; though, except some partial disorders, all remained in its ancient state ; and it is well known that volcanic commotions have very limited effects, even where they are most violent.

Of all the volcanos, or ignivomous mountains, with which so many parts of the earth abound, Mount Etna, or Gibel, in the island of Sicily, is unquestionably the most ancient on record :

> Etna roars, with dreadful ruins nigh,
> Now hurls a bursting cloud of cinders high,
> Involved in smoky whirlwinds to the sky.



Distant View of Etna.

Etna by Moonlight.

As Homer, however, who flourished about 980 years before Christ, makes no mention of a phenomenon at once so tremendous and extraordinary, this mountain is supposed not to have burned before his time. Pindar, who lived 480 years after Homer, is the first poet who has given us a description of its fiery eruptions. He has feigned the giant Typhœus to be overthrown by Jupiter, and overwhelmed by Etna, whose agitations and eruptions were caused by his vain attempts to release himself from its incumbent pressure. Of this fiction, Mr. West has given the following translation:

Now under sulphurous Cuma's sea-bound coast,
And vast Sicilia, lies the shaggy breast;
By snowy Etna, nurse of endless frost,
The pillar'd prop of heaven, for ever press'd:
Forth from whose nitrous caverns issuing rise
Pure liquid fountains of tempestuous fire,
And veil in ruddy mists the noonday skies,
While wrapt in smoke the eddying flames aspire,
Or gleaming through the night with hideous roar,
Far o'er the redd'ning main huge rocky fragments pour

But he, Vulcanian monster, to the clouds
The fiercest, hottest inundations throws,
While, with the burden of incumbent woods,
And Etna's gloomy cliffs, o'erwhelm'd he glows.
There, on his flinty bed, outstretch'd he lies,
Whose pointed rock his tossing carcass wounds:
There, with dismay he strikes beholding eyes,
Or frights the distant ear with horrid sounds.

From the building of Rome to the 79th year of the Christian era, no mention is made of Vesuvius, though it had evidently been in a prior state of activity, as Herculaneum and Pompeii, which were destroyed by the eruption of that year, are paved with lava. From the 12th to the 16th century, it remained quiet for nearly 400 years, and the crater was overgrown with lofty trees. It was descended by Bracchini, an Italian writer, a little time prior to the great eruption of 1631; the bottom was at that time a vast plain, surrounded by caverns and grottos. Etna has continued burning since the time of the poet Pindar, with occasional intervals of repose, seldom exceeding 30 or 40 years. The elevation of Etna is estimated at 10,963 feet above the level of the sea, being upwards of 2 miles. On clear days it is distinctly seen from Valetta, the capital of Malta, distant 150 miles.

The summit of Etna being above the common region of vapours, the heavens appear with unusual splendour. Brydone and his company observed, as they ascended in the night, that the number and light of the stars seemed infinitely increased. The whiteness of the milky way was like a pure flame across the heavens; and, with the naked eye, they observed clusters of stars invisible at Catania.

This one mountain contains an epitome of the different climates in the world, presenting at once all the seasons of the year, and all the varieties of produce; and it is, accordingly, divided into three zones, or regions, distinguishable as the torrid, temperate, and frigid, but known as the cultivated region, the woody, or temperate, and the frigid, or desert. The first extends through twelve miles of the ascent, is covered with towns, villages, and monasteries, is incredibly abundant in pastures, and fruit-trees of every description, and the number of inhabitants is estimated at 120,000. The woody, or temperate region is a new climate, a new creation. Below, the heat is suffocating; but here, the air is mild and fresh; the turf is covered with aromatic plants, and the gulfs which formerly ejected torrents of fire, are changed into woody valleys. There cannot be any thing more picturesque; the inequality of the soil displaying every moment some variety of scene; here, the ash and flowering thorns form domes of verdure, and there, chesnut-trees grow to a most enormous size. That called *Castagno de cento cavalli*, according to Brydone and Glover, has a circumference of 204 feet. Many oaks are also of a prodigious size. Swinburne measured one, in circumference 28 feet. The last, or desert region, commences more than a mile above the level of the sea. The lower part is covered with snow in winter only; but on the upper the snows constantly lie:

Sometimes the pencil, in cool airy halls,
Bade the gay bloom of vernal landscapes rise,
Or Autumn's varied shades imbrown the walls:
Now the black tempest strikes th' astonish'd eyes,
Now down the steep the flashing torrent flies;
The trembling sun now plays o'er ocean blue,
And now rude mountains frown amid the skies;
Whate'er Lorraine light-touch'd with soft'ning hue,
Or savage Rosa dash'd, or learned Poussin drew.

THOMSON.

The upper part, or cone, is, in a right line, about a mile in ascent. Sir William Hamilton describes it as a little mountain, a quarter of a mile perpendicular, and very steep, in a gently-inclined plane, about nine miles in circumference. The cavity was funnel-shaped, diminishing till it terminated in a point, with an outer circumference of two miles and a half. Spallanzani found the edge of the crater an oval of about a mile and a half in circuit; its edges in many places indented by projecting lavas, or scoriæ. The bottom was a plane, nearly horizontal, about two-thirds of a mile in circumference; whence, as also from the sides, issued several streams of smoke, resembling thin clouds. Within the aperture was clearly seen a liquid ignited matter, constantly undulating, boiling, rising and falling, without spreading over the bottom, doubtless the melted lava from the bottom of the gulf. None of the above travellers dared to venture down the crater, which they found too hot; but M. D'Orville, more adventurous, by ropes, held by two or three men at a distance, descended as far as possible. His view was greatly intercepted by the small flames and smoke; but in the centre he saw a mass of matter, which rose conically, about 60 feet.

In 1669, the torrent of burning lava inundated a space fourteen miles long and four broad, burying beneath a part of Catania, till precipitated into the sea. For several months preceding, the old mouth, or great crater of the summit, sent forth much smoke and flame, and the top had fallen in, so that the mountain was much lowered. Eighteen days before, the sky was very thick and dark, with thunder, lightning, frequent concussions of the earth, and dreadful subterraneous noises. On March 11, about sun-set, an immense gulf opened in the mountain; into which, stones thrown could not be heard to strike the bottom. Ignited rocks, fifteen feet long, were hurled the distance of a mile; and others, smaller, three miles. During the night, the red-hot lava burst forth, out of a vineyard twenty miles below the great crater, into the air to a considerable height. In its course it destroyed 5000 habitations, and filled up a lake several fathoms deep. It quickly reached Catania, rose above the walls, whence it ran a considerable distance into the sea, forming a safe and beautiful harbour; soon, however, filled by a similar torrent of inflamed matter. This is the stream, whose hideous deformity, devoid of vegetation, still disfigures the south and west borders of Catania, and on which part of the noble modern city is built.

The showers of scoriæ and sand, which, after a lapse of two days, followed this eruption, formed a mountain called Mont Rosæ, having a base of about two miles, and a perpendicular height of 750 feet. On the 25th, the whole mountain, even to the most elevated peak, was agitated by a tremendous earthquake. The highest crater, the loftiest part of the mountain, then sunk into the volcanic gulf; and nothing appeared but a wide gulf, more than a mile in extent, whence issued enormous quantities of smoke, ashes, and stones.

In 1809, twelve new craters opened, about half way down the mountain, and threw out rivers of burning lava, by which several estates were covered, to the depth of thirty or forty feet; and during three or four successive nights, a very large river of red-hot lava was distinctly seen, in its whole extent, running down from the mountain.

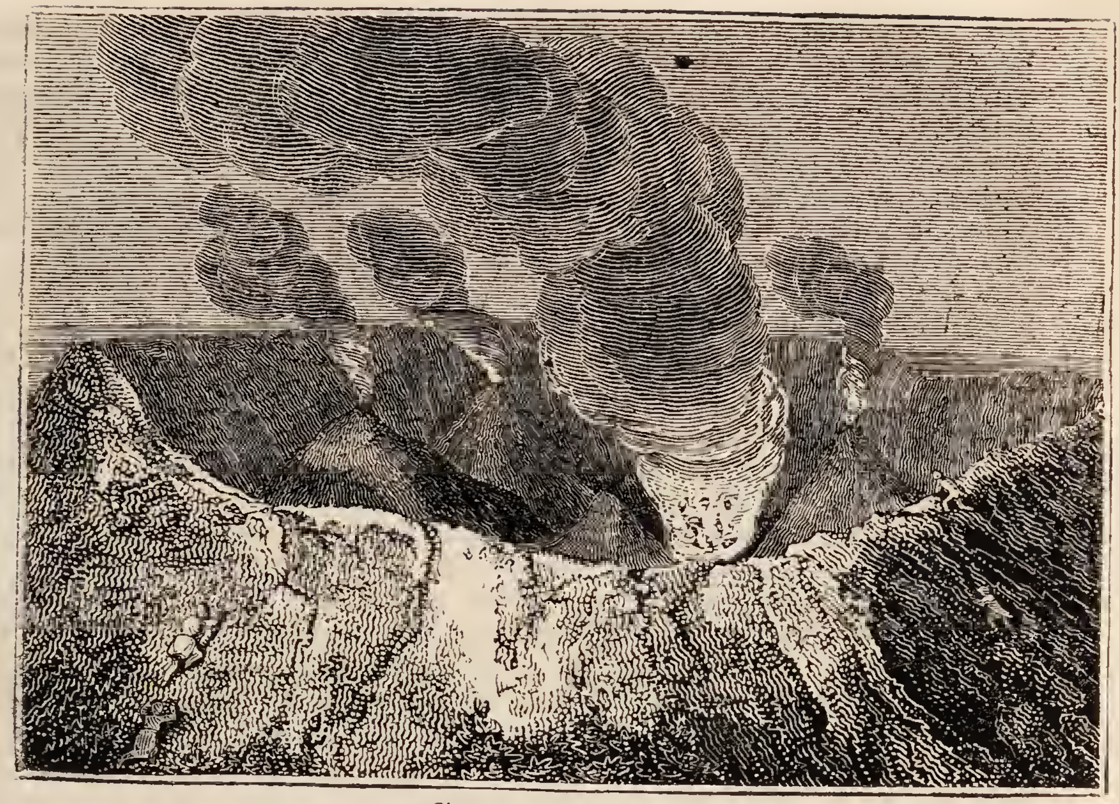
In 1811, several mouths opened on the eastern side of the mountain; being nearly in the same line, and at equal distances, they presented a striking spectacle,—torrents of burning matter, discharged with the greatest force from the interior of the volcano, illuminated the horizon to a great extent. An immense quantity of matter, driven to considerable distances, was discharged from these apertures; the largest, for several months emitted torrents of fire.

M. Gourbillon, in his recent Travels, gives the following interesting account of his visit to Etna in 1819:

"We set out at three o'clock from Catania, and began our march in frightful roads, amidst rocks of lava, which cover the first part of the route. We continued our journey in a road covered with lava, but bordered with superb Indian fig trees. After proceeding five or six miles, we passed through the village of Gravelina; where I was assailed by nearly the whole population demanding charity. Some miles further we perceived, and afterwards passed through, another village, called Masca-Luscia: it contains two churches; one of which, nearly destroyed by an earthquake, was never very remarkable, and the other is only rendered so, by a steeple fantastically decorated with stones of various colours. We arrived, in fine, at the last village, that of Nicolosi, which appeared poorer than all the rest; this was surely, in former times, the Town of Etna, where the inhabitants of Catania took refuge, on the arrival of the Greeks; the environs abound in olive trees, and vineyards which produce excellent wine. All this part was covered with ashes by the eruption of Monte Rosso, a secondary volcano which formed itself at the time of the last eruption. Monte Rosso is one of those mountains by which Etna is surrounded. It appears that when an eruption takes place, the lava making its way on the flanks of the mountains, pierces the ground in the place which offers the least resistance, and there forms a swelling, which it afterwards consolidates by flowing from above. In this village we found the guide, or, as he is called, the Pilot of Etna. After some conversation, he engaged to ascend for three piastres, about twelve shillings and sixpence. From thence to the convent, where we were to rest our beasts, we had no more than a mile to go, which we performed by coasting along Monte Rosso, whose summit was gilded by the sun, and behind which it had already set, when we arrived. This mountain is several miles in circumference. I profited by the last light of the sky, in order to sketch a view of the convent, which, although of the common extent, is nevertheless picturesque. Built against a small hill, long since become cold, and covered with woods, it seems sheltered from the destructive effects of the volcano; from the other side, between superb fir trees, you perceive the sea, the plains of Catania and Syracuse. We were four hours in coming from Catania, which is, notwithstanding, only a distance of twelve miles. I slept here, and we set out at half past nine, by moonlight. We first entered into an immense torrent of lava; the uncertain glimmerings of the moon gave an extraordinary aspect to the huge masses by which I was surrounded. Soon after, long shadows scattered here and there, and a trembling of the leaves, announced the approach to the forest of oaks, which formerly encircled Etna to the height of several miles; but which an immense torrent of lava had ravaged. We now entered into the most fantastical lavas; they have more of a slope, and the crevices which form there, as soon as they become cold, acquire more extent, and present a more rent appearance.

I was sorry not to have brought a thermometer, but I was not able to find one for sale, either at Messina or at Catania. Some have found the elevation of Etna to be 12,000 feet, and others 24,000. Cassini reckons 10 fathoms for the falling line of the mercury, by adding 1 to the first 10, 2 to the second, &c., but he has never surely made the experiment of his method on very high mountains, where the air is rarefied in a much more rapid progression. Etna might be measured trigonometrically, for it descends as far as the sea, the shore being taken for the base. We may even have an approaching idea of its elevation, by the time which the sun's light takes in descending from its summit to the sea*.

* In returning from Alexandria to Marseilles in the month of March, I saw Etna covered with snow. A calm having lasted some hours, I profited by it, to take the height of this mountain. With the aid of a mariner's compa..., I perceived that the Cape Sparti-Vento, in Calabria, reached us by the N.N.E., andCape Passaro, in Sicily, by the S.W.; I was then sure of the point where I found myself on the chart. (We made use on board of the French charts of the Mediterranean, which are very good.) This point being at a distance of



Crater of Etna.

Crater of Vesuvius.

Having arrived near a mass of snow which filled one of the narrow passes of the mountain, a summit which looked black in the sky, made me believe that I was at the end of the journey; an old tower which I took for the *Torre del Filosofo*, confirmed me in my error. I soon after perceived another summit covered with a whitish smoke; I asked if it was much higher than the other: my guide affirmed that it was, and he was in the right, for it seemed to me to surpass the first, in the whole height of Vesuvius. The road became more united, and the acclivity gentler. We coasted along a torrent of black lava, the more singular, as its elevation was from 8 to 10 feet, and perpendicular like a wall, which clearly proved to me, that this matter, in flowing, is not in perfect fusion; as a great part of the substances which it drags along, are sufficiently hard to prevent their melting, and that they are like the basalt, detached from the immense vaults which during many ages supported this natural forge. The sky began to adorn itself in the east, and we perceived the house called *Les Anglais.* After a light breakfast I directed my steps towards the place where, according to custom, the curious go to behold the rising sun.

I now bent my steps towards the last summit, which, covered with a light white smoke, seemed to move away from the impatient traveller. We walked nearly a mile on an almost horizontal lava, or, to speak more correctly, on striated scoriæ, or dross, which made a crackling noise under our feet, and soon after on a swamp of snow, where we found a large round stone, 3 feet in diameter, of the species of those called volcanic balls, which the mountain throws up in great eruptions; but it is only a grain of metal in comparison with the volcano, which ejected it from its bosom. In fine, we mounted the last cone which supports the crater; the ashes and the stones slipping under our feet. The cold was excessive, but exercise kept us warm; I quitted my cloak, and rolling up in it some pieces of lava, I left it on the mountain. At last we arrived on the borders of the crater; but the wind was so violent, that I could scarcely cast a glance over it. I was thrown down, and had it not been for my *cicerone*, I might have rolled to the foot of the declivity which had given us so much trouble to ascend. Fastened and lying down on the ridge of the crater, I considered it at my ease, and braved the fury of Æolus and Vulcan. (See *the Engraving*.)

It is a vast aperture, having 4 summits of different heights, rather more than a mile in width, and, on account of its inequalities, I should think it about 4 in circumference. It is divided into 2 craters,

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60 miles from the foot of the axis of Etna, I measured at that time the angle which the summit of the mountain made with the horizon; it was found to be 6 degrees; which gave me a rectangular triangle of which I knew a side and the 3 angles, the one right, the other of 6 degrees, and the third of 84 degrees. The base being of 60 miles, there remained for me only to make the following proportion.

$$Sin.\ 84^\circ : 66 \text{ miles} :: Sin.\ 6^\circ : 4\frac{24}{84}$$

The result is found to be, for the axis side of Etna, 4 miles and 24-84ths, above 4½ miles, or 20,400 feet, for the total height. This measure is not perhaps perfectly correct, but, at least, it approximates very near to it. If this height appears surprising, we ought to consider that other great mountains have never been measured but with the barometer, and that Mr. Brydone was surprised to see the mercury here descending nearly 2 inches lower than on the summit of the Alps.

by a cone rising from its centre, and which forms a crater itself, the slope of which is not very rapid. The ancient aperture is united to this cone by a gentle declivity, where has probably been formed within a recent period, a small crater, a partial volcano, a perfect truncated cone, from whence issues a great quantity of smoke. The general aspect of the crater is much less dreary than that of Vesuvius; the substances surrounding it are not so black, but have rather the colour of potter's earth. It is now 6 years since Etna has made an eruption, but it has given concussions which have alarmed the inhabitants of Catania and overthrown some houses. I attribute its silence and its tranquillity, not to the extinction of the fires, for they still rage in its bosom, but to the great vacuum which must necessarily exist under this enormous vault. The whole of the mountain being formed only by what it has seized and driven out of the bowels of the earth, we might reasonably think that an interior vacuum, perhaps equal to the half of the exterior mass, must exist; at least that it is not filled with water, as some persons have believed. However this may be, it appears that in great eruptions, all the cones, all the partial volcanos formed in the crater, are thrown to the outside; which must then make a frightful aperture by its extent and profundity. I do not know whether, when this cone is considerably enlarged, its weight alone makes it fall into the gulf, the vaults of which have no longer the force to sustain it, or whether the eruption suffices to cause this displacement. This question can never be well decided; for it would then require that chance should place an observer on the borders of the crater, and, in that case, he would run a great risk never to be able to relate what he had seen.

I could not make the entire tour of the crater on account of the violence of the wind, which prevented me also from descending into the interior, which appeared to me less rapid than that of Vesuvius.

I shall now explain to you the ideas which the sight of Vesuvius and Etna has left on my mind. Volcanos are certainly the most surprising objects we meet with on the surface of our globe. Allow me to suppose that one man alone inhabits it; that he walks about in his domains; where will he find fire, unless a thunder-bolt falls at his feet, or that he arrives near to a volcano, near to Etna for instance? We may judge of his astonishment, at the sight of a mountain different from all others. Huge stones, of which the whole is the true image of chaos, would at first appear to him a barrier to his arriving at the summit; but a deafening noise is heard, the entire mountain roars, a thick cloud of smoke rises up and becomes white, a light, of which he cannot conceive the cause, covers the top, and escapes in sparkling sheaves; if curiosity has triumphed over his fear, he braves all obstacles, he traverses the snow, and at last he arrives at the summit. Some red-hot stones are still strewed under his feet; should he lay hold of one, what will he think of the pain he experiences? Thus, of how many mythological tales has Etna been the theatre! It was there that were found the forges of Vulcan, the cavern of the terrible Polyphemus, that monstrous Cyclop, from whose voracity Ulysses had so much difficulty in escaping; the people believe still that Etna is the sojourn of demons—a door of hell.

This Etna is truly an image of the earth; it may be compared to one of the two hemispheres, of the north or of the south; its icy summit resembles the pole, and is not susceptible of culture: its temperate zone, on the contrary, presents the finest vegetation. The superb forest which surrounds it, like a covering of verdure, and its base, where the torrents of lava, finding less declivity, extend the more, resemble the countries situated between the two tropics; some plants are even found there, such as the date tree, which are peculiar to them."

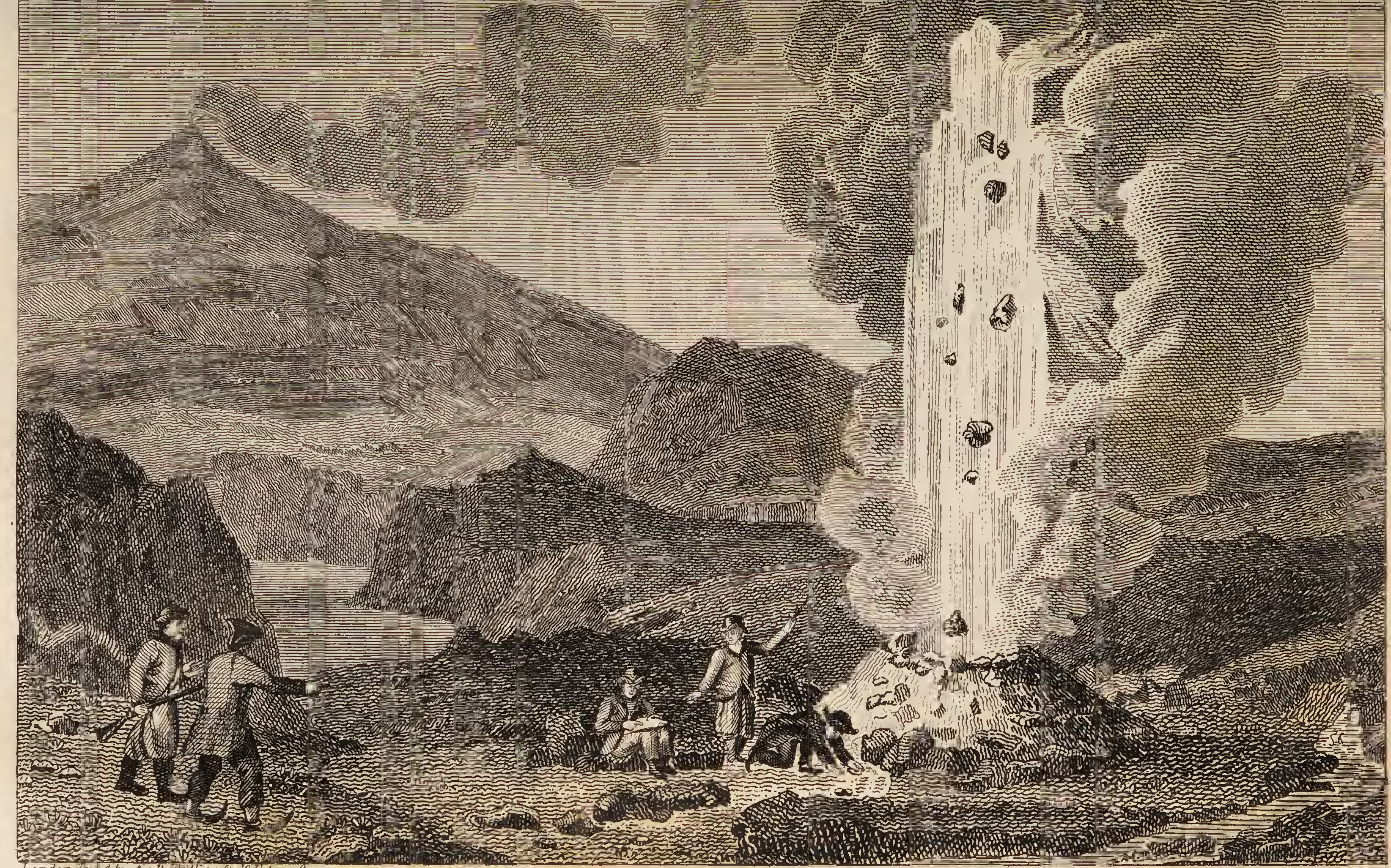
M. Ostervald, in his splendid work, published in Paris, in 1822, and entitled, "*Voyage Pittoresque en Sicile,*" gives the following account of the great crater of Etna:

"Above the snows, which to a distant beholder seem to crown Etna, and to be in immediate contact with the orifice of that immense volcano, there exists a vast and unequal space, a desolate and frightful region, incessantly beaten by an impetuous wind, or covered with sulphurous clouds, agitated by continual workings, which daily change its aspect and its dangers, and composed of the remains of the most violent eruptions, or of the more tardy products of the continual fermentation operating within the crater, even in its ordinary and accessible state. In the midst of this arid, burning, and chaotic waste, rises an ultimate eminence, steep and uneven, down the sides of which roll at every moment the torrified substances emitted from the interior of the crater, at short intervals, and with loud detonations. Yet this instantaneous ejection of cinders, lava, and scoriæ, is not sufficient to deter the audacious traveller, who is determined on attaining a station whence he may contemplate the gulf, of which this frightful cone forms as it were the crown. In ascending the exterior slope of this apex, the feet are sometimes buried in loose cinders, or recoil with the rubbish, that gives way at every step; sometimes they slip from the smoother parts, which the mephitic clouds have covered with humidity. Still, the heat of this unstable ground allows no time for taking breath, even when the extreme rarefaction of the air, at an elevation of 10,000 feet above the level of the sea, might alone cause great difficulty of respiration. Exhalations from the crater descend in volumes down the sides of the mountain, producing, when met with, a painfully suffocating sensation, and augmenting the terror and dismay caused by the explosions that are heard from the interior of the volcano, echoing and reverberating in abysses, of which the imagination dares not conceive the extent or profundity. At each detonation the mountain appears to quake; scoriæ, ashes, and calcined stones glide in black furrows along its declivity, and render the access still more perilous. In many cases, it is only by going on hands and knees, and by attaching themselves one to another with cords, that persons find it possible to attain the extreme verge of the great opening, from whence the eye can scarcely take in the vast circumference at a single view. In fact, the crater of Etna has not the aspect of an almost regular funnel; it appears rather to be a gulf, the periphery of which, unequal in its outline and elevation, is divided by numerous crevices; and presents, in a circle of nearly a league in extent, a succession of salient and retiring angles, lateral cavities, deep fissures, and sharp projections, several of which form so many particular craters, in a state of incandescence.

The interior surface of the crater, which has almost the aspect of an artificial excavation, is furrowed with crevices, from whence are emitted, with some noise, and at brief intervals, sheaves of fire and whirling clouds of smoke, the greater part of which, after rising to a considerable height, fall down again into the very gulf. The burning lava, the ashes, and the calcined fragments, are frequently shot to the exterior of the crater; glittering scoriæ explode in the air, like sky-rockets, and roll away at a distance down the slope of the mountain. Some travellers have seen torrents of lava escape from the cavities of the interior declivity, in a state of fusion, and flow down the abyss, where they were lost in the sinuosities of an irregular, but apparently bottomless funnel. Yet this fearful spectacle may be comtemplated from a still nearer point of view; and some intrepid observers have penetrated down the sloping sides into the very interior of the crater; in which, at the depth of 25 or 30 feet, occurs a sort of shelf or corniche, from whence a closer inspection may be obtained, though not without extreme danger, of this imposing scene. Sometimes the bottom appeared covered with ashes and rubbish; sometimes it was overspread with a dense vapour impenetrable to the sight. There were moments when it was possible to distinguish the sinuosities of an abyss, winding amidst calcined rocks, to the depth of about 600 feet; at other times, an interior cone, crowned with a second crater, rose from the midst of the cavity; at a more recent period, this immense basin seemed to be divided in several places by immense partitions, formed of lava and scoriæ. But whatever be the state of the gulf, its sublime and terrible aspect, and the dreadful phenomena of which it is the scene, appal the understanding and strike the imagination. But if, on turning at once from the contemplation of these horrible wonders, the beholder directs his view away from the crater, toward the immense horizon which expands around Etna, a contrast of the most delightful kind enchants his eye, and revives his oppressed spirits. All Sicily, her cities, her harbours, her rivers, her rich plains, and the sea which forms her superb cincture, seen from this prodigious elevation, form a picture indescribably magnificent. Torrents of light stream over those fertile valleys, those azure waves, and those mountains that seem dwindled into little hills in the presence of this frowning and gigantic volcano."

Vesuvius is situated about seven miles east of Naples, upon a vast and well-cultivated plain, presenting two summits on the same base. One, La Somma, is the Vesuvius of Strabo and the ancients; the other, being the most elevated, is the mouth of the volcano, which mostly emits smoke. Its summit above the level of the sea, is 3,900 feet; and may be ascended by three different routes, very steep and difficult, from the conical form of the mountain, and the loose ashes, which slip from under the feet; the distance, however, from the base to the summit is not more than three Italian miles. The circumference of the platform, on the top, is 5,024 feet. Thence may be seen Portici, Capræa, Ischia, Pausilippo, and the gulf of Naples, bordered with orange trees; the prospect, that of Paradise seen from the infernal regions.

On approaching the mountain, its aspect is neither terrific nor gloomy, being cultivated more than two-thirds of its height, its brown top alone being barren. Yet, when covered with clouds, which sometimes encompass its middle only, this barrenness rather increases, than diminishes, the magnificence of the spec-



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Mount Hecla and the Boiling Spring of Geyser.

Craters of Etna, by Brydone.

Principal Cone and Crater of Etna.

tacle. Upon the lavas long ejected, and which, like great furrows, extend into the plain, and to the sea, stand houses, villages, and towns, with gardens, vineyards, and cultivated fields; but sentiments of sorrow, blended with apprehensions of the future, arise on recollecting that, beneath a soil so fruitful and smiling, lie edifices, gardens, and whole towns. Portici rests upon Herculaneum; its environs upon Resina; and at a short distance is Pompeii, in whose streets, after more than 17 centuries of non-existence, the astonished traveller now walks.

A very great eruption of this mountain took place in 1669. The progress of the lava, or fiery deluge above described, was at the rate of a furlong a day. It advanced into the sea 600 yards, and was then a mile in breadth. It destroyed, in forty days, the habitations of 27,000 persons; and of 20,000 inhabitants of the city of Catania, only 3000 escaped. This inundation of liquid fire, in its progress, met with a lake 4 miles in compass, and not only filled it up, although it was only 4 fathoms deep, but raised it into a mountain. Borelli, an ingenious Neapolitan, has calculated, that the matter discharged at this eruption was sufficient to fill a space of 93,838,750 cubic paces. The lava which ran from it, is 14 miles in length, and, in many parts, 6 in breadth.

The violent eruption of Vesuvius, in 1767, is reckoned the 27th since that which destroyed the cities of Herculaneum and Pompeii, in the reign of emperor Titus; and this eruption of 1767 has been succeeded by several others. *(See Plate 1.)*

The eruption of 1779 has been described by Sir William Hamilton, as among the most remarkable, from its extraordinary and terrific appearance. During the whole of July the mountain was in a state of considerable fermentation, subterraneous explosions and rumbling noises being heard, and quantities of smoke thrown up with great violence, sometimes with red-hot stones, scoriæ, and ashes. On Aug. 5th, the volcano was greatly agitated, a white sulphureous smoke, apparently four times the height and size of the volcano, issuing from the crater, while vast quantities of matters were thrown up to a vast height; the liquid lava, having cleared the rim of the crater, flowed down the sides of the mountain to the distance of 4 miles; the air was thickened by showers of reddish ashes, blended with long filaments of vitrefied matter resembling glass. On the 7th, at midnight, a fountain of fire shot up to an incredible height, casting so bright a light, that the smallest objects were distinguishable 6 miles from the volcano.

Next evening, after a tremendous explosion, which broke the windows of the houses at Portici, another fountain rose to the surprising height of 10,000 feet (nearly 2 miles), while its splendid brightness was interrupted here and there by puffs of the blackest smoke. The lava was, by the wind, directed partly towards Ottaiano, on which fell so thick a shower of ashes, blended with vast pieces of scoriæ, that, had it continued longer, that town would have shared the fate of Pompeii. The horror of the scene was augmented by incessant volcanic lightning darting through the black cloud, while the sulphureous smell and heat would scarcely allow breathing; and this dreadful state continued nearly half an hour. The remaining lava, red-hot and liquid, fell on the top of Vesuvius, and covered its cone, with that of La Somma, and the intermediate valley, thus forming an intense body of fire, not less than 2 miles and a half broad, and casting a heat at least 6 miles round.

In the eruption of 1794, although the town of Torre del Greco was instantly surrounded with red-hot lava, the inhabitants saved themselves by coming out of the tops of their houses on the following day. "Had this lava," observes Mr. Kirwan, "been hot enough to melt even the most fusible stones, these persons must have been suffocated." This eruption happened June 15, at 10 o'clock at night, and was announced by a shock of an earthquake, distinctly felt at Naples. At the same moment a fountain of bright fire, with a very black smoke and a loud report, rose to a considerable height, from about the middle of the cone. It was hastily succeeded by other fountains, 15 in a direct line, tending, for about a mile and a half, towards Resina and Torre del Greco. This fiery scene was accompanied by the loudest thunder, whose incessant reports, like those of a numerous heavy artillery, were attended by a continued hollow murmur. At this moment the sky, from a bright full-moon and star-light, became obscured; the moon seemed eclipsed, and was soon invisible.

Next day a new mouth was opened on the side, facing Ottaiano; from which aperture a considerable stream of lava ran with great velocity through a wood, which it burnt, about 3 miles in a few hours, but stopped before it reached the vineyards and cultivated lands. The lava from several new mouths on the south side, reached and ran into the sea, after having overwhelmed, burnt, and destroyed much, by passing through the centre of Torre del Greco, which contained about 18,000 inhabitants, but all escaped, except about 15, through age or infirmity, overwhelmed in their houses. Its rapid progress was such, that the goods and effects were entirely abandoned. It was ascertained afterwards, that on the west side part of the crater had fallen in, and greatly extended the mouth of Vesuvius. This sinking opposite Naples probably occurred early on the morning of the 18th; as a violent shock of an earthquake was felt at Resina. The clouds of smoke from the widely-extended mouth, were so dense as with the utmost difficulty to force their passage. One cloud heaped on another, and succeeded incessantly; in a few hours they formed such a gigantic and elevated column of the darkest hue, over the mountain, as seemed to threaten Naples with immediate destruction, it being, at one time, bent over the city, and appearing much too massive and ponderous to remain long suspended.

Plate 2 is a view of Mount Vesuvius, and of Somma, taken from Posilipo, July 6th, 1794, when it could be clearly distinguished.

Pláte 3 represents the enormous cloud of smoke and ashes, replete with ferilli, or volcanic lightning, which first threatened destruction to the town of Naples on the 18th of June, 1794; and afterwards, from the impulse of the sea wind, bent over the mountain of Somma, and

Pl. II

VESUVIUS IN 1794.

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poured its destructive contents on the town situated at the foot of that mountain, beating in the roofs of the houses, and involving all the inhabitants of the Campagna Felice in darkness and danger. This view was taken from Naples, and gives a very good idea of the appearance of Mount Vesuvius, like a mole-hill, in comparison with the enormous mass that hung over it.

In 1804 Vesuvius gave symptoms of a fresh eruption, for several months, and on the night of August 11th, a deep roaring was heard at the Hermitage of Salvador, and the places adjacent, accompanied by shocks of an earthquake, sensibly felt at Resina. Next day, at noon, a thick black smoke rose from the mouth of the crater, which, dilating prodigiously, covered the whole. In the evening, loud explosions were heard; and a column of fire was seen, at Naples, to rise from the aperture, carrying up stones in complete ignition, which fell again into the crater. The noise which accompanied these igneous explosions resembled the roaring of a most dreadful tempest, and the whistling of the most furious winds; while they were ejected with such celerity, that ere the first emission had terminated it was succeeded by a second. Small monticules were formed of a fluid matter, resembling a red vitreous paste, from the mouth of the crater; which became more considerable as the matter accumulated.

Thus the eruption continued, the fire equally intense, with frequent and dreadful noises, till on the 28th, amid these fearful symptoms, another aperture, ejecting fire and stones, behind the crater, was seen from Naples. The burning mass of lava which escaped on the following day, was obvious from Torre del Greco, appearing as a vitreous fluid, and advancing, south and south-west, towards the base of the mountain, which it reached on the 30th; its course was into four branches, and finally reached a spot called the Guide's Retreat, having flowed, in 24 hours, a distance of 3,053 feet, its mean breadth being about 350, but at the base 860 feet. Its entire progress was more than a mile, so that, taking a mean proportion, it flowed 86 feet in an hour.

The great eruption of 1805 happened on the 12th of August, within a day of that of the preceding year. Subterraneous noises had been previously heard, and a general apprehension of some violent commotion prevailing, the inhabitants of Torre del Greco and Annunciada had left their homes, through the apprehension of a shower of fire and ashes, similar to that which buried Pompeii. The stream of lava took the same course with that of 1794. It swept along with it enormous masses of whatever occurred in its course, and, on reaching the sea there was to be seen or heard for a great extent of shore, only the boiling and hissing arising from the conflict of the water and fire.

The eruption of 1806, without any sensible indication, took place on the evening of May 31, when a bright flame rose about 600 feet high, sinking and rising alternately, and affording so clear a light, that a letter might have been read at the distance of a league around the mountain. On the following morning, without any earthquake preceding, as was customary, the volcano ejected inflamed substances from three new neighbouring mouths, and about 650 feet from the summit. The lava took the direction of Torre del Greco and Annunciata, approaching Portici, on the road from Naples to Pompeii. The whole of June 2, a noise was heard, resembling discharges of artillery and musketry, from two armies engaged. The current of lava now resembled a wall of fused glass, whence sparks and flashes issued, with a loud detonation. Vines, trees, houses,—whatever objects it encountered, were instantly overthrown or destroyed. This eruption continued till September, made great ravages, and was one of the most terrible in the memory of the inhabitants.

"Vesuvius," says Dr. Clarke, "is in all respects, as to its chemical nature, a vast blow-pipe, corresponding in all its phenomena, with the appearances and effects, the explosions and detonations, the heat and the light, exhibited by the apparatus which bears this name; and differing from it only as the mighty operations of nature, in the universe, differ from the puny imitations of the chemist, in his laboratory. No volcanic eruption takes place without the agency and decomposition of water. Hence," says Dr. Clarke, "before any great eruption of Vesuvius, not only does the water disappear in all the wells in Naples, Portici, Resina, and other towns at the foot of the mountain, but even the sea itself retires."

It is curious to observe, that while volcanos spread such wide and incessant destruction in South America, they are totally unknown in the northern part of the American continent. In 1600, a volcano in Peru covered an area of ground, above 34,000 square acres, with sand, ashes, and other matter.

"In September, 1783, I received," says M. Titsingh, in his work on Japan, "from Yedo the following particulars of the dreadful ravages occasioned by the eruption of the volcano, Asama-ga-daki, in the districts of Djozou and Zinzou. At eight o'clock in the morning, there arose in the province of Sinano, a very strong east wind, accompanied with a dull noise, like that of an earthquake, which increased daily. In 4 days there was a tremendous noise, and a shock of an earthquake; the walls of the houses cracked, and seemed ready to tumble; each successive shock was more violent, till the flames burst forth, with a terrific uproar, from the summit of the mountain, followed by a tremendous eruption of sand and stones: though it was broad day, every thing was enveloped in profound darkness, through which the flames alone threw at times a lurid light. For three days the mountain never ceased to cast up sand and stones. The large village of Sakamoto, and several others, situated at the foot of the volcano, were soon reduced to ashes, by the ignited matter which it projected, and by the flames which burst from the earth. (*See the Engraving.*) The inhabitants fled; but the chasms, every where formed by the opening of the ground, prevented their escape, and in a moment a great number of persons were swallowed up or consumed by the flames. The water of the rivers Yoko-gawa and Carousawa boiled; the course of the Yone-gawa, one of the largest rivers of Japan, was obstructed, and the boiling water inundated the adjacent country. The bears, hyænas, and other beasts of prey, fled from the mountains, and flocked to the neighbouring villages, where they devoured the inhabitants, or mangled tnem in a horrible manner. The number of dead bodies floating upon the rivers was incalculable. Twenty-seven villages were swallowed up, and four only escaped, namely, Matsyeda, Yasouye, Takasakie, and Fousie-oka. At the last of these places there fell a shower of red-hot stones, each weighing 4 or 5 ounces. At 2 o'clock the same day, the mountain of Asama cast forth a torrent of flames and balls of fire, and the whole country was enveloped in darkness. Many other villages, besides those here named, either partly disappeared with their inhabitants, or were swept away."

Java, one of the finest islands in the world, is almost entirely volcanic. In 1586, there was an eruption which

Pl. III

COLUMN OF SMOKE THIRTY MILES HIGH ISSUING FROM VESUVIUS.

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killed 10,000 persons. In 1772, a great part of the Passandayang was swallowed, with violent explosions. Forty villages were destroyed; 2957 inhabitants, and 15 miles in length and 6 of breadth ingulfed. But a more extraordinary eruption was that of Tomboro, a mountain in Sambawa, in 1815. So tremendous was this explosion, that its effects extended over the Molucca Islands, Java, and a large portion of Celebes, Sumatra, and Borneo, to a circumference of 1000 miles from its centre, by tremulous motions; and the report of the explosion was heard at Java, 300 miles distant; while showers of ashes fell upon the island, and totally darkened the atmosphere. The ashes lay an inch and a half deep at Macassar, distant 250 miles. The sea was, for many miles round Sambawa, so covered with pumice-stone and trunks of trees, as to impede the progress of ships; and the atmosphere was, for 2 entire days, in total darkness. The explosions were not only heard at Java, and the before-mentioned islands, but at Banca and Amboyna; the latter 890 miles distant, the former 986.

This latter eruption is thus described in Raffles's History of Java:—"The first explosions were heard in the eveuing of the 5th of April, 1815: they were noticed in every quarter, and continued at intervals until the following day. The noise was, in the first instance, universally attributed to distant cannon. On the following morning, however, a slight fall of ashes removed all doubt as to the cause of the sound; and it is worthy of remark, that as the eruption continued, the sound appeared to be so close, that in each district it seemed near at hand, and was generally attributed to an eruption, either from the mountains Merapi, Klut, or Bromo. From the 6th, the sun became obscured; it had every where the appearance of being enveloped in a fog. The weather was sultry and the atmosphere close, and still the sun seemed shorn of its rays, and the general stillness and pressure of the atmosphere seemed to forbode an earthquake. This lasted several days. The explosions continued occasionally, but less violently, and less frequently than at first. Volcanic ashes also began to fall, but in small quantities, and so slightly as to be hardly perceptible in the western districts. This appearance of the atmosphere continued, with little variation, until the 10th of April. On the evening of the 10th, the eruptions were heard more loud and more frequent; from Cheribon, eastward, the air became darkened by the quantity of falling ashes; the sun was nearly darkened; and in some situations, particularly at Solo and Rembang, many said that they felt a tremulous motion of the earth. It was universally remarked, in the more eastern districts, that the explosions were tremendous, continuing frequently during the 11th, and of such violence as to shake the houses perceptibly. An unusual thick darkness was remarked all the following night, and the greater part of the next day. At Solo, candles were lighted at 4 *p. m.* of the 12th; at Mágelan, in Kédu, objects could not be seen at 300 yards' distance. At Grésik, and other districts more eastward, it was dark as night on the greater part of the 12th of April, and this saturated state of the atmosphere lessened as the cloud of ashes passed along and discharged itself on its way. Thus the ashes that were 8 inches deep at Banyuwángi were but 2 in depth at Súmenap, and less in Grésik; and the sun does not seem to have been actually obscured in any district west of Semárang.

The haziness and heat of the atmosphere, and occasional fall of volcanic ashes, continued until the 14th, and in some parts of the island until the 17th of April. They were cleared away universally by a heavy fall of rain, after which the atmosphere became clear and more cool. In Rembang, where the rain did not fall till the 17th, and the ashes had been considerable, the crops were somewhat injured: but in Banyuwángi, the part of the island on which the cloud of ashes spent its force, the injury was more extensive.

The Rajah was himself a spectator of this eruption, of which he gave the following account. About 7 *p. m.* on the 10th of April, three distinct columns of flame burst forth near the top of the Tomboro mountain (all of them apparently within the verge of the crater), and after ascending separately to a very great height, their tops united in the air, in a troubled confused manner. In a short time, the whole mountain next Sang'ir appeared like a body of liquid fire, extending itself in every direction. The fire and columns of flame continued to rage with unabated fury, until the darkness, caused by the quantity of falling matter, obscured it at about 8 *p. m.* Stones, at this time, fell very thick at Sang'ir; some of them as large as two fists, but generally not larger than walnuts. Between 9 and 10 *p. m.* ashes began to fall, and soon after a violent whirlwind ensued, which blew down nearly every house in the village of Sang'ir, carrying the ataps, or roofs, and light parts away with it. In the part of Sang'ir adjoining Tomboro its effects were much more violent, tearing up by the roots the largest trees, and carrying them into the air, together with men, horses, cattle, and whatever else came within its influence. The sea rose nearly 12 feet higher than it had ever been known to do before, and completely spoiled the only small spots of rice-land in Sang'ir, sweeping away houses and every thing within its reach. The whirlwind lasted about an hour. No explosions were heard till the whirlwind had ceased, at about 11 *a. m.* From midnight till the evening of the 11th, they continued without intermission; after that time their violence moderated, and they were only heard at intervals, but the explosions did not cease entirely until the 15th of July. Of the whole village of Tomboro, containing about 40 inhabitants, only one remained."

In 1816, Mr. Brande published an account of an extraordinary natural phenomenon in the plains of Grobogan, in Java, 50 miles NE. of Solo.

A party, that set out from Solo to examine it, on approaching the village of Kuhoo, saw, between 2 trees in a plain, an appearance like the surf breaking over rocks, with a strong spray falling leeward. The spot was completely surrounded by flats, for the manufacture of salt. Alighting, they went to the bludugs, as the Javanese call them, and found them to be on an elevated plain of mud, about 2 miles in circumference; in the centre of which, immense bodies of salt mud were thrown up, to the height of from 10 to 15 feet, in the forms of large globes, which bursting, emitted volumes of dense white smoke.

At times they threw up 2 or 3 tons of mud. As the globes burst, they threw the mud out from the centre with a loud noise, occasioned by the falling of the mud upon that which surrounded it, of which the plain is composed. It was difficult and dangerous to approach the large globes or bubbles, as the ground was all a quagmire, except where the surface of the mud had become hardened by the sun; upon this they approached cautiously, to within 50 yards of the largest bubble, or mud pudding. They also got close to a small globe or bubble (the plain was full of them, of different sizes), and observed it closely for some time. It appeared to heave and swell, and when the internal air had raised it to some height, it burst, and the mud fell down in concentric circles, in which shape it remained quiet, until a sufficient quantity of air was again formed internally, to raise and burst another bubble. This continued, at intervals, from about one-half to two minutes. From various other parts of the quagmire, round the large globes or bubbles, there were occasionally small quantities of mud shot up, to the height of 20 or 30 feet, accompanied by smoke. The mud, at all places they came near, was cold on the surface, but they were told it was warm beneath. The water which drains from the mud is collected by the Javanese, and by being exposed, in the hollows of split bamboos, to the rays of the sun, deposits crystals of salt.

Almost all the mountains or volcanos in Java are found, on examination, to have the same general constitution: they are striped vertically, by sharp ridges, which, as they approach the foot of the mountain, take a more winding course. These ridges alternate with valleys, whose sides are of various declivities.—Large rocks of basalt occasionally project, and in several instances the valleys form the beds of rivers towards the tops of the volcanos; in the rainy season they all convey large volumes of water.

Next in importance to this extensive series of primary mountains, there are various ridges of smaller mountains, or hills, extending in different directions, with nearly an equal degree of elevation; sometimes originating from or connected with the primary volcanos, sometimes forming independent ranges, and arising separately and at a distance from the great series. These, which have been termed secondary mountains, though evidently of a volcanic nature, differ in many particulars of their constitution from those of the larger series. They generally extend in long narrow ridges, with but a moderate elevation, and their sides are less regularly composed of the vertical ridges above mentioned. In most cases, a stratified structure and submarine origin may be discovered. They are generally covered with large rocks of basalt; and in some instances they consist of wacken and hornblende, which is found along their base, in immense piles.

Alluvial districts, evidently of recent origin, are noticed in several parts of the island. These are formed from the sediment, and near the discharge of large rivers, and at the borders of the calcareous ridges, which are in many instances partially covered by them: their boundary can easily be traced, and most of them are still in a state of constant progression. Among other phenomena are mineral wells, of various temperature and impregnation; wells of naphtha, or petroleum; and rivers, arising, in a few instances, from the craters of volcanos, impregnated with sulphureous acid.

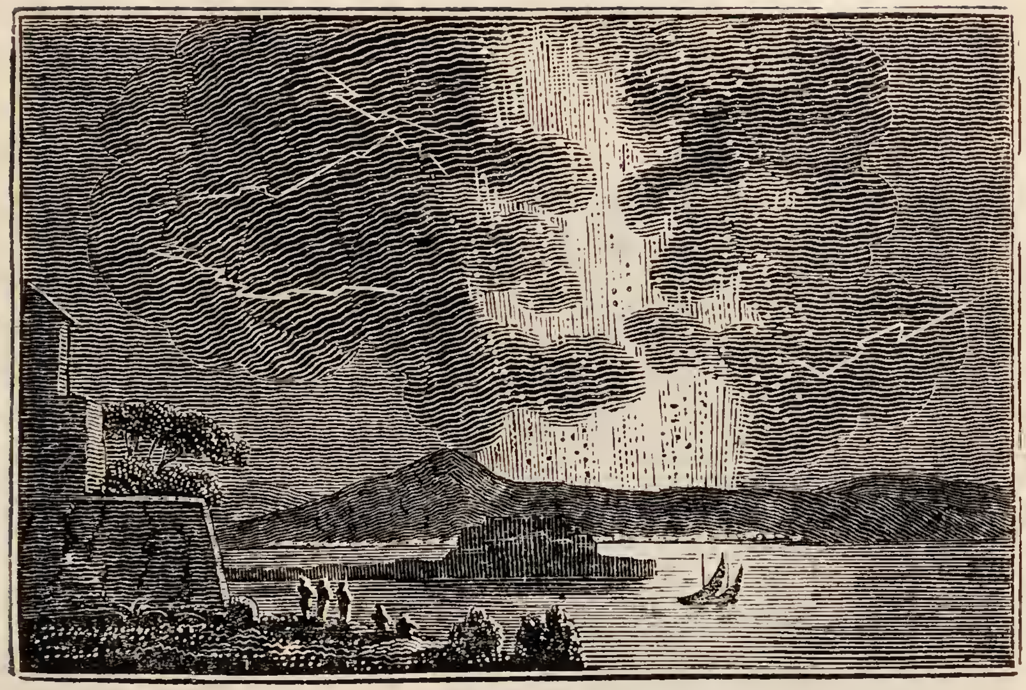
From these, and all other investigations yet made, the constitution of Java appears to be exclusively volcanic. From the vast Asiatic chain of mountains, one branch of which terminates in Ceylon, proceeds another, which, traversing Arakan, Pegu, and the Malayan peninsula, extends to Sumatra, Bánka, and Bíliton, where it may be said to disappear. On Java, no granite has been discovered. In its constitution, as in its direction, it may be considered as the first of a series of volcanic islands, which extend nearly eastward from the Straits of Sunda for about 25 degrees.

It is related, that in former times the islands of Sumatra, Java, Bali, and Sumbawa were united, and afterwards separated into 9 different parts; and it is also said, that when 3000 rainy seasons have passed away, they will be re-united.

The separation of the lands of Palembang (Sumatra) and Java took place in the Javan year	1114
The separation of the lands of Bali and Balembangan on Java in	1204
The separation of the lands of Giling, Trawangân, and Bali in..	1260
The separation of the island of Selo-Parang and Sumbawa in....	1280

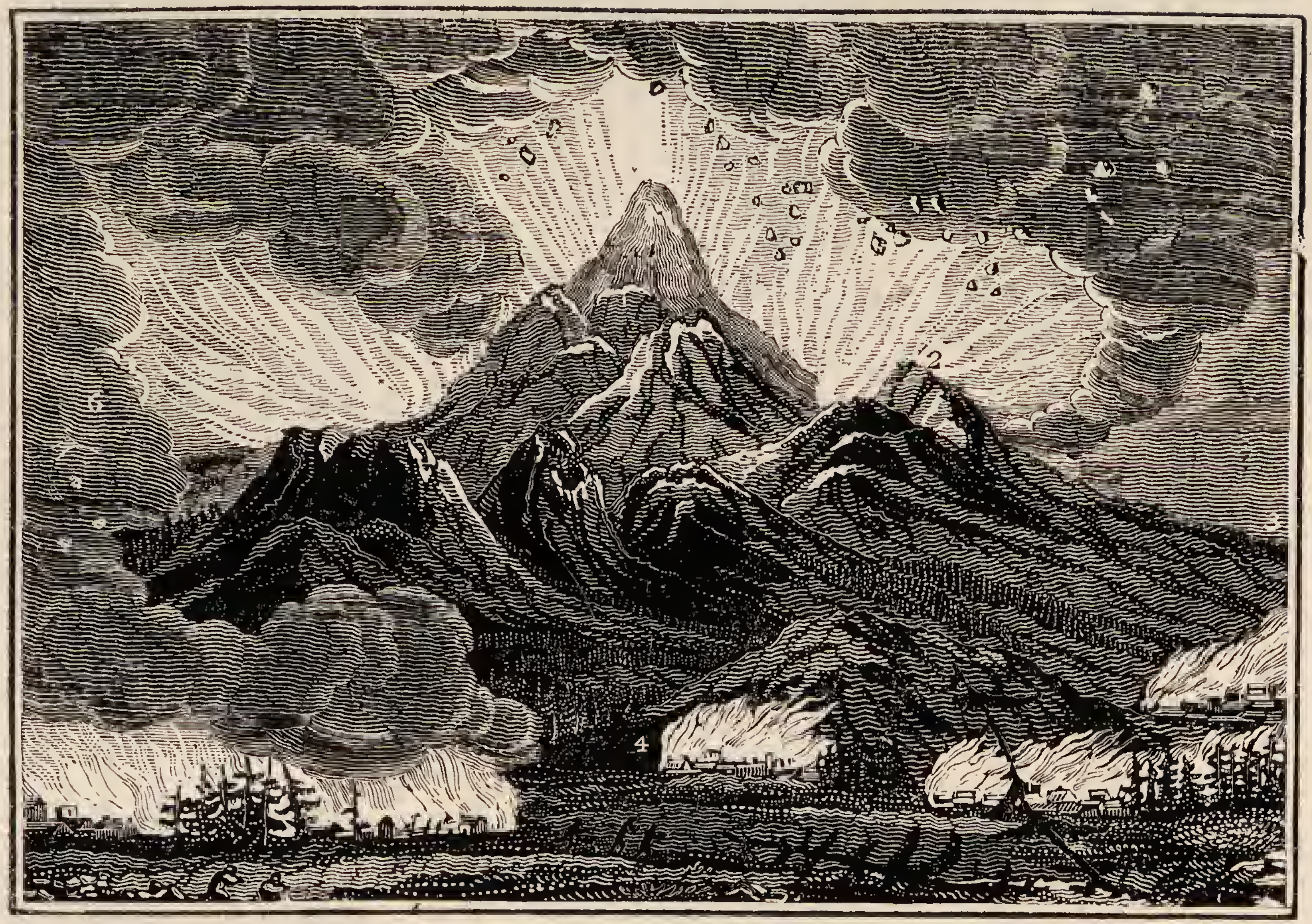
STROMBOLI is the principal of the Lipari Isles, lying north of Sicily, all of which contain volcanos. At a distance, its form appears an exact cone, but it is a mountain with two summits, of different heights, whose sides have been torn and shattered by craters. The highest summit, inclining SW., is about a mile high.

From the more elevated summit, the inner part of the burning crater, and its mode of eruption, may be seen. It is about half-way up, on the NW. side of the mountain, and has a diameter of 250 feet. Burning stones are thrown up, at intervals of seven or eight minutes, ascending in diverging rays. While a portion rolls down towards the



Eruption of Vesuvius, from Naples.

Stromboli.



Volcano in Japan.

sea, the greater part fall again into the crater, and are again cast out, until they are reduced to ashes. The volcano, however, constantly supplies others, and seems inexhaustible. In the more violent eruptions, the ejected matter rises half a mile, or higher; many of the ignited stones being thrown above the highest summit.

These erupted stones appear black in the day-time, but at night of a deep red colour, and sparkle like fire-works. Each explosion is accompanied by clouds of flame or smoke, the lower part black, the upper white and shining, in globular and irregular forms. In high winds, from the S. or SE., the smoke spreads over every part of the island. On a particular night, when the wind blew with great violence, the clear sky resembled a beautiful aurora borealis, over that part where the volcano is situated, and from time to time became more red and brilliant, as the ignited stones were thrown higher.

The present crater has burned more than a century, without any apparent change of situation. In rolling down, the lava raises the fine sand like a cloud of dust. While this was observed by Spallanzani, the volcano suddenly made an eruption. Numerous pieces of dark red lava, enveloped in smoke, were ejected from the top of the precipice, and thrown high into the air. A part fell on the declivity, and rolled down, the smaller preceded by the greater; and, after a few bounds, dashed into the sea, giving out a sharp hissing sound.

On the night following, the volcano raged with greater violence, and rapidly hurled very high thousands of red-hot stones. Those which rolled down the precipice produced a hail of streaming fire, which illuminated the steep descent. Independent of these ignited stones, there was in the air, over the volcano, a vivid light, not extinguished when that was at rest. It was not properly flame, but real light, reverberated by the atmosphere. Besides varying in intensity, it appeared in constant motion, ascending, descending, dilating, and contracting, but always perpendicular over the mouth of the volcano, which showed that its cause was the conflagration within the crater. The detonations in the greater eruptions resembled distant thunder; in the more moderate, the explosions of a mine; and in the smallest, they were scarcely audible. Each was some seconds later than the ejection.

Lipari, which has given name to the whole cluster, deserves notice for its celebrated stoves, the only vestiges of subterraneous conflagration, and which lie west of the city, on the summit of a mountain of considerable elevation, called *Monte della Stufe*, the *Mountain of Stoves*. They consist of 5 excavations, like grottoes; 2 have been abandoned because of the great heat, which might cause suffocation.

Vulcano, the last of the Lipari isles, bears in every part the mark of fire. It consists of a mountain, in the form of a truncated cone; merely a case, exposing a second cone within, more exact than the other, and the mouth of the volcano.

Dolomieu represents the crater of Vulcano as the most magnificent he ever saw; and Spallanzani observes, that except that of Etna, he does not know any more capacious and majestic. It exceeds a mile in circuit, and has an oval mouth, while its depth is a quarter of a mile. The bottom is flat, and from many places streams of smoke exhale, emitting a strong sulphureous vapour. With the aid of a glass, two small lakes, supposed to be filled with melted sulphur, have been discovered. The declivity of the interior walls is so great, that even when there is no danger from fire, the descent is next to impossible. After considerable difficulty, however, this was accomplished by Spallanzani. He found the bottom of an oval form, more than one third of a mile in circumference. The subterraneous noise was here much louder than on the summit, sounding like an impetuous river foaming beneath; or, rather, like a conflict of agitated waves, meeting and clashing furiously together.

In Iceland is an immense sulphur mountain, distant about 3 miles from Krisukif, and presenting a remarkable phenomenon, that of a caldron of mud.

At the foot of the mountain is a small bank, composed chiefly of white clay and sulphur, from every part of which steam issues. This mountain has often been ascended, and on one occasion the party having ascended this bank, a ridge presented itself, having immediately beneath a deep hollow, whence arose a profusion of vapour, with a confused noise of boiling and splashing, while steam escaped from narrow crevices in the rock. This hollow, and the whole side of the mountain opposite, being covered with sulphur and clay, was very hazardous to traverse. The vapour, concealing the party from each other, occasioned much uneasiness; there was some hazard of the crust of sulphur breaking, or of the clay sinking beneath their feet: and the thermometer, immersed in it a few inches, generally rose within a few degrees of the boiling point. The mud was in constant agitation, and often thrown up 6 or 8 feet. Near this spot an irregular space, filled with water, was boiling briskly. At the foot of the hill, from loose fragments of rock, in a hollow formed by a bank of clay and sulphur, steam rushed with great force and noise. In ascending the mountain, says the narrator of this expedition, is a spring of cold water, little to be expected in such a place. At a greater elevation is a ridge, entirely of sulphur and clay, joining two summits of the mountain. The smooth crust of sulphur was beautifully crystallized; and beneath, a quantity of loose granular sulphur appeared to be collecting and crystallizing, as it was sublimed along with the steam.

Beneath the ridge, on the farther side of this great bed of sulphur, much vapour escapes, with a loud noise. Opposite is the principal spring. About half a mile of the side of the mountain was covered with loose clay, into which their feet sunk at every step; many places having a thin crust, beneath which the clay was wet, and extremely hot. A dense column of steam, mixed with a small portion of water, forces its way through a crevice in the rock, at the head of a narrow break in the mountain, with such violence that the noise might often be heard several miles.

In 1783, a submarine volcano broke out near Iceland, which formed a new island; it raged with great fury for several months. The island afterwards sunk, leaving only a reef of rocks. In December, 1720, a violent earthquake was felt at Tercera, one of the Azores; the next morning a new island, 9 miles in circumference, was seen, from the centre of which rose a column of smoke; it afterwards sunk to a level with the sea.

Near the little island of Santori, in the Grecian archipelago, submarine volcanos have repeatedly burst forth during the last 2000 years, and formed several new islands: three of the ancient eruptions are recorded by Pliny, Strabo, and Seneca. The last eruption was in the year 1767. The number of volcanos has been estimated at near 200; but they may be supposed greatly to exceed this estimate, if we consider those volcanos as only dormant, and not extinct, which still present indications of subterranean heat.

In the Azores there are no less than 42 active or dormant volcanos; almost all the islands in the Atlantic, and many in the Pacific Ocean and the Indian Seas are volcanic. A range of active and dormant volcanos extends from the southern extremity of America to the arctic circle. Numerous volcanos exist in Iceland; and the hot sulphurous exhalations, from craters in various parts of Italy, prove that their internal fires are not extinguished.

The hot springs in the valley of Reikholt, or Reikiadel, though not the most magnificent, are perhaps the most curious among the numerous phenomena of this sort that are found in Iceland.

Sir George Mackenzie, in his Travels in Iceland, says, "on entering the valley, we saw numerous columns of vapour ascending from different parts of it. The first springs we visited, issued from a number of apertures in a sort of platform of rock, covered by a thin coating of calcareous incrustations. From several of the apertures the water rose with great force, and was thrown 2 or 3 feet into the air. On plunging the thermometer into such of them as we could approach with safety, we found that it stood at 212°.

A little farther up the valley, there is a rock in the middle of the river, about 10 feet high, 12 yards long, and 6 or 8 feet in breadth. From the highest part of this rock, a jet of boiling water proceeded with violence. The water was dashed to the height of several feet. Near the middle, and not more than 2 feet from the edge of the rock, there is a hole, about 2 feet in diameter, full of water, boiling strongly. There is a third hole near the other end of the rock, in which water also boils briskly. At the time we saw these springs, there happened to be less water in the river than usual, and a bank of gravel was left dry, a little higher up than the rock. From this bank a considerable quantity of boiling water issued.

About a mile farther down, at the foot of the valley, is the Tungahver, an assemblage of the most extraordinary springs. A rock rises from the bog, about 20 feet, and is about 50 yards in length. Along the face of the rock are arranged no fewer than 16 springs, all of them boiling furiously, and some of them throwing the water to a considerable height. One of them, however, deserves particular notice. On approaching this place, we observed a high jet of water, near one extremity of the rock. Suddenly this jet disappeared, and another, thicker, but not so high, rose within a very short distance of it. At first we supposed that a piece of the rock had given way, and that the water had at that moment found a more convenient passage. We observed that there were 2 irregular holes in the rock, within a yard of each other; and while from one a jet proceeded to the height of 12 or 14 feet, the other was full of boiling water. We had scarcely made this observation, when the first jet began to subside, and the water in the other hole to rise; and as soon as the first had entirely sunk down, the other attained its greatest height, which was about 5 feet. In this extraordinary manner these two jets played alternately. The smallest and highest jet continued about 4 minutes and a half, and the other about 3 minutes. This spring may be distinguished by the name of the ALTERNATING GEYSER."

Nor stops the restless fluid, mounting still,
Though oft amid th' irriguous vale of springs;
But to the mountain, courted by the sand,
That leads it darkling on in faithful maze,

Far from the parent-main, it boils again
Fresh into day; and all the glittering hill
Is bright with spouting rills.———

The crystal treasures of the liquid world,
Through the stirr'd sands a bubbling passage burst;
And welling out, around the middle steep,
Or from the bottoms of the bosom'd hills,
In pure effusion flow. THOMSON.

Fell Geyser roar'd, and struggling shook the ground;
Pour'd from red nostrils, with her scalding breath,
A boiling deluge o'er the blasted heath;
And, wide in air, in misty volumes hurl'd,
Contagious atoms o'er the alarmed world. DARWIN.

"The geysers are about 16 miles to the north of Skalholt. To the eastward of Skalholt are several hot springs, and others rise among the low hills, which we left on the right hand in going to the geyser. Further on, we found some cottages at the foot of the mountain; round which we turned, and came in sight of the hill, on one side of which are the geysers. This hill, which does not exceed 300 feet in height, is separated from the mountain, towards the west, by a narrow stripe of flat boggy ground, connected with that which extends over the whole valley.

On the east side of the hill there are several banks of clay, from some of which steam arises, in different places; and in others there are cavities, in which water boils briskly. In a few of these cavities the water, by being mixed with clay, is thick, and varies in colour; but it is chiefly red and grey. Below these banks there is a gentle and uniform slope, composed of matter which, at some distant period, has been deposited by springs that no longer exist. The strata, or beds thus formed, seemed to have been broken by the shocks of earthquakes, particularly near the great geyser. Within a space not exceeding a quarter of a mile, there are numerous orifices in the old incrustations, from which boiling water and steam issue, with different degrees of force; and at the northern extremity is the great geyser, sufficiently distinguishable from the others by every circumstance connected with it. On approaching this place, it appeared that a mount had been formed of irregular, rough-looking depositions, upon the ancient regular strata, whose origin has been similar. The slope of the latter has caused the mount to spread more on the east side, and the recent depositions of the water may be traced till they coincide with them. On the top of this mount is a basin, which we found to extend 56 feet in one direction, and 46 in another.

When we arrived on the spot, we found the basin full of hot water, a little of which was running over. We next went to examine some other places, whence we saw vapour ascending. Above the great geyser, at a short distance, is a large irregular opening, the beauties of which it is hardly possible to describe. The water which filled it was as clear as crystal, and perfectly still, though nearly at the boiling point. Through it we saw white incrustations, forming a variety of figures and cavities, to a great depth; and carrying the eye into a vast and dark abyss, over which the crust supporting us formed a dome of no great thickness.

We pitched our tent at the distance of about 100 yards from the geyser, and arranged matters so that a regular watch might be kept during the night. About 10 minutes before 12, I heard subterraneous discharges, and waked my friends. The water in the basin was greatly agitated, and flowed over, but there was no jet. The same occurred at half-past 2. At 5 minutes past 4, on Saturday morning, an alarm was given. I instantly drew aside the canvas next the door, when at a distance of little more than 50 yards, we saw water thrown up, and steam issuing, with a tremendous noise. There was little water; but the force with which the steam escaped, produced a white column of spray and vapour, at least 60 feet high.

Following the channel, which has been formed by the water escaping from the great basin during the eruptions, we found some beautiful and delicate petrifactions. The leaves of birch and willow were seen converted into white stone, and in the most perfect state of preservation, every minute fibre being entire. Grass and rushes were in the same state, and also masses of peat. On the outside of the mount of the geyser, the depositions, owing to the splashing of the water, are rough, and have been justly compared to the heads of cauliflowers. They are of a yellowish brown colour, and are arranged round the mount, somewhat like a circular flight of steps. The inside of the basin is comparatively smooth; and the matter forming it is more compact and dense than the exterior crust; and, when polished, is not devoid of beauty, being of a grey colour, mottled with black and white spots and streaks. The white incrustation, formed by the water of the beautiful cavity before described, had taken a very curious form at the edge of the water, very much resembling the capital of a Gothic column."

Sir George Mackenzie has deduced the following theory of the geysers, which was formed on the spot

"Were the appearances regular in duration, and the intervals between the jets always equal, it would not be difficult to construct an apparatus which would exhibit them with precision; but in both respects, as well as in the degree of violence, there is great irregularity. From whatever source the heat proceeds, whether from the combustion of beds of coal, the decomposition of pyrites, or any other cause, there can be no hesitation in granting the possibility of a greater quantity of heat being evolved at one time than at another; or of the heat remaining steady at intervals. It is not merely possible, but very probable, that the wonders of the geysers are caused by sudden productions of heat. By such a supposition they may easily be explained, by help of an extremely simple apparatus; but, without it, a very complicated system of pipes and cavities, and perhaps, too, of valves, will be necessary.

A column of water is suspended in a pipe, by the expansive force of steam, confined in cavities under the surface. An additional quantity of steam can only be produced by more heat being evolved. When heat is suddenly evolved, and elastic vapour suddenly produced, we can at once account for explosions, accompanied by noises. The accumulation of steam will cause agitation in the column of water, and a farther production of vapour. The pressure of the column will be overcome, and the steam escaping will force the water upwards along with it.

As long as the extraordinary supply of steam continues, these oscillations and jets will go on. But at every jet some of the water is thrown over the basin, and a considerable quantity runs out of it. The pressure is thus diminished; the steam plays more and more powerfully, till at last a forcible jet takes place, a prodigious quantity of steam escapes, and the remaining water sinks into the pipe.

Another way of accounting for the operations of these extraordinary fountains, which appears equally plausible with what has been stated, has been suggested. It requires the existence of a strongly heated surface, free from water; and also, that of a small subterraneous fountain, operating like the little geyser we have described, expelling its water occasionally, so that it flows over the heated surface, by which means an additional quantity of steam may be temporarily produced. But this explanation is perhaps more deficient than the other; for if we suppose the water, which is to be suddenly converted into elastic vapour, to be furnished from a small subterraneous fountain, the operations of that fountain must be explained, and the same difficulties, that remain to be overcome in the case of the geyser, meet us in this; as they must also do in whatever mode we may suppose water to be supplied."

Of the volcanos in northern Asia, or the interior of Africa, we have little information, and the volcanos covered by the sea cannot be estimated; but from the above statement, we are authorized in believing, that volcanic fires are more extensively operative on the surface of the globe, than many geologists are disposed to admit. Their source is deep under the surface of the earth, and many circumstances indicate that a connexion exists between volcanos at a vast distance from each other.

In 1783, when the submarine volcano near Iceland suddenly ceased, a volcano broke out 200 miles distant, in the interior of the island, and at the same time the great earthquakes took place in Calabria. On the night in which Lima and Callao were destroyed by an earthquake, 4 new volcanos broke out in the Andes. Other instances of the apparent connexion of earthquakes with distant volcanos have been before stated. Were the source of volcanic fires near the surface, the country in their vicinity would sink down; and it is impossible to conceive how the same volcano could continue its eruptions incessantly, for more than 2000 years. Fragments of rocks, such as lime and gypsum, are thrown out of volcanos unchanged by fire, which proves that the source of heat was far below the range of these rocks; they have been merely driven up by the subterranean explosion, which forced a passage through them.

From the various phenomena which volcanos present, we may with probability infer, that the internal part of our planet is in an igneous state, however difficult it may be to explain in what manner this heat is generated and confined. Had all the volcanos in the world been dormant for the last 2000 years, and were we only acquainted with their existence by the writings of ancient historians, we should discredit the fact, and prove its impossibility by an appeal to established chemical principles: we should further accompany the proof with a pathetic lamentation over the credulity of former times.

The descent of stones from the atmosphere was denied during a longer period though the fact is now established beyond all doubt. Admitting the existence of central fire in the earth, it is not difficult to conceive that there may be determinate causes by which its intensity is increased or diminished at certain periods. We know little respecting the operation of electric or voltaic energy, in the laboratory of nature; but from the existence of electric light at the poles, we may infer that electric currents are passing through the ducts which are found in the craters of volcanos. Sulphureous and sulphuric acids are formed by the combustion of sulphur during eruptions; these act upon lavas and rocks, and produce different combinations, of which the most important are alum, sulphate of magnesia, gypsum, and green copperas. Hydrogen and sulphuretted hydrogen are emitted from volcanos in vast quantities. Whether phosphorus be a product of volcanos is unknown: its extreme inflammability prevents it from being discovered in a concrete form; but the dense white clouds, resembling bales of cotton, which sometimes cover Vesuvius, resemble the fumes produced by the combustion of phosphorus. Among the products of volcanos, we find only three substances which are combustible in the atmosphere; sulphur, hydrogen, and a small portion of carbon; but it has been conjectured by Sir H. Davy that the earths and alkalis, which form lavas, exist in the centre of the globe in a metallic state, and take fire by the access of water. This property of the newly-discovered metals, to inflame instantly on the access of water, by which they are converted into earths or alkalis, offers an easy explanation of the origin of volcanic fires, could we suppose that substances so extremely inflammable and oxydable have remained for ages in a metallic state. There may, however, be processes, in the vast laboratory of the globe, that constantly separate the earths from oxygen, and prepare them for the support of volcanic fires, by which they are thrown upon the surface, and a connexion is established between the internal and external parts of the planet.

The force with which all volcanic products are thrown is astonishing. In the year 1769, a stone, 12 feet high, and 4 in circumference, was thrown to the distance of a quarter of a mile from the crater; and in the year 1771, Sir William Hamilton observed stones of an enormous size, which employed 11 seconds in falling. This indicates an elevation of near 2000 feet. The eruption of volcanos is frequently aqueous; the water, which is confined, and favours the decomposition of the pyrites, is sometimes strongly thrown out. Sea-salt is found among the ejected matter, and likewise sal ammoniac. In the year 1630, a torrent of boiling water, mixed with lava, destoyed Portici and Torre del Greco. Sir W. Hamilton saw boiling water ejected. The springs of boiling water in Iceland, and all the hot springs which abound at the surface of the globe, owe their heat only to the decomposition of pyrites.

The eruption which buried Herculaneum is of the same kind as the Mud Volcano, in Java. Sir W. Hamilton found an antique head, the impression of which was well enough preserved to answer the purpose of a mould. Herculaneum, at the least depth, is 70 feet under the surface of the ground, and in many places 120.

The puzzolano is of various colours. It is usually reddish, sometimes grey, white, or green. It frequently consists of pumice-stone, in powder, but sometimes it is formed of oxided clay. One hundred parts of red puzzolano afforded Bergmann, silex 55, alumina 20, lime 5, iron 20. When the lava is once thrown out of the crater, it rolls in large rivers down the side of the mountain to a certain distance, which form the currents of lava, the volcanic causeways, &c. The surface of the lava cools, and forms a solid crust, under which the liquid lava flows. After the eruption, this crust sometimes remains, and forms hollow galleries, which Messrs. Hamilton and Ferber have visited; it is in these hollow places that the sal ammoniac, the muriate of soda, and other substances, sublime. A lava may be turned out of its course by opposing banks or dykes against it; this was done in 1669, to save Catania; and Sir William Hamilton proposed it to the King of Naples, to preserve Portici. The currents of lava sometimes remain several years in cooling. Sir William Hamilton observed, in 1769, that the lava which flowed in 1766 was still smoking, in some places.

Lava is sometimes swelled up and porous*. The lightest is called pumice-stone. The substances thrown out by volcanos are not altered by fire. They eject native substances, such as quartz, crystals of amethyst, agate, gypsum, amianthus, felspar, mica, shells, schorl, &c. The fire of volcanos is seldom strong enough to vitrify the matters it throws out. The slow operation of time decomposes lavas, and their remains are very proper for vegetation. The fertile island of Sicily has been every where volcanized. Chaptal observed several ancient volcanos at present cultivated; and the line which separates the other earth from the volcanic earth, constitutes the limit of vegetation.

The ground over the ruins of Pompeii is highly cultivated. Sir William Hamilton considers subterranean fires as the great vehicle used by Nature to extract virgin earth out of the bowels of the globe, and repair the exhausted surface. The decomposition of lava is very slow. Strata of vegetable earth, and pure lava, are occasionally found applied one over the other; which denote eruptions made at distances of time very remote from each other, since in some instances it appears to have required nearly 2000 years before lava was fit to receive the plough. In this respect, however, lavas differ very widely, so that our reasoning from them must at best be very vague.

Besides the convulsions of Nature displayed in volcanos already noticed, other operations are carried on below the fathomless depths of the sea, the nature of which can only be conjectured by the effects produced. Nor is it more astonishing that inflammable substances should be found beneath the bottom of the sea, than at similar depths on land, and that there also the impetuous force of fire should cause the imprisoned air and elastic gases to expand; and, by its mighty force, should drive the earth at the bottom of the sea above its surface. These marine volcanos are perhaps more

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* Several chemists have analyzed the lava of the last eruption of Vesuvius, and M. Pepe has discovered in it the following ingredients: sulphate of potash, sulphate of soda, sub-sulphate of alumine, of chalk, and of magnesia; hydro-chlorate of potash, that of soda, a good deal of oxide of aluminium, calcium, silicium, and magnesium; much trioxide of iron, antimony, and a little gold and silver. Other substances, which the mountain continues to throw out, are very different from the preceding. This eruption appears to favour the hypothesis that the volcanic fire may be produced by the infiltration of the sea-water, in the masses of potassium, sodium, &c. which are not yet oxidated; and the production of electrical fluid in such great abundance may arise from the same source, since the effects of the voltaic pile (*auge*) are obtained by the oxidation of metals.

frequent, though they do not so often come within the reach of human observation, than those on land; and stupendous must be the operations carried on, when matter is thrown up to an extent which the ingenuity of man does not enable him to reach by fathoming.

Many instances have occurred, as well in ancient as in modern times, of islands having been formed in the midst of the sea; and their sudden appearance has constantly been preceded by violent agitations of the surrounding waters, accompanied by dreadful noises, and, in some instances, by fiery eruptions from the newly-formed isles, which are composed of various substances, frequently intermixed with a considerable quantity of volcanic lava. Such islands remain for ages barren, but in a long course of time become abundantly fruitful. It is a matter of curious inquiry, whether springs are found on such newly created spots, when the convulsions which gave them birth have subsided.

Seneca asserts, that, in his time, the island of Therasea, in the Egean sea, was seen to rise in this manner, by several mariners who were sailing near the point of its ascent. Pliny's relation is still more extraordinary; for he says, that in the Mediterranean, 13 islands emerged at once from the sea.

The Grecian Archipelago and the Azores are the grandest and most surprising instances of this phenomenon. The island of Acroteri appears to have its surface composed of pumice-stone, encrusted by a surface of fertile earth; and it is represented by the ancients as having risen, during a violent earthquake, from the sea. Four neighbouring islands are described as having had a similar origin, notwithstanding the sea is in that part of the Archipelago of such a depth as to be unfathomable by any sounding-line. These arose at different times: the first, long before the commencement of the Christian era; the second in the first century; the third in the eighth; and the fourth in 1573.

On the 22d of May, 1707, a severe earthquake was felt at Stanchio, an island of the Archipelago; and on the ensuing morning, a party of seamen, discovering not far off what they believed to be a wreck, rapidly rowed towards it; but finding rocks and earth instead of the remains of a ship, hastened back, and spread the news of what they had seen, in Santorini, another of these islands. However great the apprehensions of the inhabitants were at first sight, their surprise soon abated, and in a few days, seeing no appearance of fire or smoke, some of them ventured to land on the new island. Their curiosity led them from rock to rock, where they found a kind of white stone, which yielded to the knife like bread, and nearly resembled that substance in colour and consistence. They also found many oysters sticking to the rocks; but while they were employed in collecting them, the island moved and shook under their feet, on which they ran with precipitation to their boats. Amid these motions and tremblings the island increased, not only in height, but in length and breadth: still, occasionally, while it was raised and extended on the one side, it sunk and diminished on the other.

The narrator of this last fact observed a rock to rise out of the sea, 40 or 50 paces from the island, which, having been thus visible for 4 days, sunk, and appeared no more: several others appeared and disappeared alternately, till at length they remained fixed and unmoved. In the mean time the colour of the surrounding sea was changed: at first it was of a light green, then reddish, and afterwards of a pale yellow, accompanied by a noisome stench which spread itself over a part of the island of Santorini. On the 16th of July smoke first appeared, not indeed on the island, but issuing from a ridge of black stones which suddenly rose about 60 paces from it, where the depth of the sea was unfathomable. Thus there were 2 separate islands, one called the White, and the other the Black Island, from the different appearances they exhibited. This thick smoke was of a whitish colour, like that of a lime-kiln, and was carried by the wind to Santorini, where it penetrated the houses of the inhabitants. On the 31st of July the sea smoked and bubbled in two different places near the island, where the water formed a perfect circle, and looked like oil when beginning to simmer. This continued above a month, during which time many fishes were found dead on the shore of Santorini. On the following night a dull hollow noise was heard, like the distant report of several cannon, which was instantly followed by flames of fire, shooting up to a great height in the air, where they suddenly disappeared. On the 7th of August a noise was heard, resembling that of large stones thrown, at very short intervals, into a deep well. This noise, having lasted for some days, was succeeded by another much louder. On the 21st the fire and smoke were very considerably diminished; but the next morning they broke out with still greater fury than before. At night, by the means of a telescope, 60 small openings or funnels, all emitting a very bright flame, were discovered on the highest part of the island, conjointly resembling a large furnace; and on the other side of the great volcano there appeared to be as many. On the morning of the 23d, the island was much higher than on the preceding day, and its breadth increased by a chain of rocks which had sprung up in the night nearly 50 feet above the water. On the 5th of September, the fire opened another vent at the extremity of the Black Island, from which it issued for several days. The following night the sub-aqueous fire made a terrible noise, and immediately after a thousand sheaves of fire darted into the air, where breaking and dispersing, they fell like a shower of stars on the island, which appeared in a blaze. To these natural fireworks succeeded a meteor, which for some time hung over the castle of Scaro, and which resembled a flaming sword. On the 9th of September, the White and Black Islands united; after which the western end of the island grew daily in bulk. There were now 4 openings only which emitted flames: these issued forth with great impetuosity, sometimes attended with a noise like that of a large organ-pipe, and sometimes like the howling of wild beasts. On the 12th the subterraneous noise was much augmented. On the 18th of September an earthquake was felt at Santorini. The claps were also more terrible than ever; and in the midst of a thick smoke, which appeared like a mountain, large pieces of rock, which afterwards fell on the island, or into the sea, were thrown up with as much noise and force as balls from the mouth of a cannon. One of the small neighbouring islands was covered with these fiery stones, which being thinly crusted over with sulphur, gave a bright light, and continued burning until that was consumed. On the 21st, a dreadful clap of subterraneous thunder was followed by very powerful lightnings, and at the same instant the new island was so violently shaken, that part of the great furnace fell down, and huge burning rocks were thrown to the distance of 2 miles and upwards. All was quiet for several days after: but on the 25th, the fire broke out again with still greater fury. The volcano continued to rage during the remaining part of the year; and in the month of January, 1708, the large furnace, without one day's intermission, threw out stones and flames, at least once or twice, but generally 5 or 6 times a day. On the 10th of February, in the morning, a pretty strong earthquake was felt at Santorini. The 15th of April was rendered memorable by the number and violence of the bellowings and eruptions, by one of which nearly 100 stones were thrown at the same instant into the air, and fell again into the sea at about 2 miles distant. From that day, until the 22d of May, which may be considered as the anniversary of the birth of the new island, things continued much in the same state, but afterwards the fire and smoke subsided by degrees, and the subterraneous thunders became less terrible. From July 15, until the 15th of August, the fire, smoke, and noises continued. The most recent account is that of a traveller, who, in 1811, passed this island at some distance. It appeared to him like a stupendous mass of rock, but was not inhabited or cultivated. It had then long ceased to burn.

Similar eruptions of islands have occurred in the group of the Azores. Thus, in December, 1720, a violent earthquake was felt on the island of Tercera. On the following morning a new island, which had sprung up in the night, made its appearance, and ejected a huge column of smoke. This island was larger on its first appearance than at some distance of time afterwards; it at length sunk beneath the level of the sea, and is now no longer visible.

In the Transactions of the Royal Society, for the year 1812, Captain Tillard has published the following very interesting narrative of a similar phenomenon, which occurred in the same sea, near the Azores.

" Approaching the island of St. Michael's, on Sunday, the 12th of June, 1811, in the Sloop Sabrina," says he, " under my command, we occasionally observed, rising in the horizon, 2 or 3 columns of smoke, such as would have been occasioned by an action between 2 ships, to which cause we universally attributed its origin. Having, however, heard, prior to our sailing from Lisbon, that in the preceding January or February a volcano had burst out within the sea near St. Michael's, we immediately concluded that the smoke we saw proceeded from that cause, and, on our anchoring the next morning in the road of Ponta del Gada, we found this conjecture correct as to the cause, but not as to the time; the eruption of January having totally subsided, and the present one having burst forth only 2 days prior to our approach, and about 3 miles distant from the one before alluded to.—Desirous of examining as minutely as possible a contention so extraordinary between two such powerful elements, I set off from the city of Ponta del Gada on the morning of the 14th. After riding about 20 miles across the

St. Michael's marine Volcano.

Hecla.

north-west end of the island of St. Michael's, we came to the edge of a cliff, whence the volcano burst suddenly upon our view in the most terrific and awful grandeur. It was only a short mile from the base of the cliff, which was nearly perpendicular, and formed the margin of the sea. Imagine an immense body of smoke rising from the sea, the surface of which was marked by the silvery rippling of the waves, occasioned by the light and steady breezes incidental to those climates in summer. In a quiescent state, it had the appearance of a circular cloud revolving on the water like an horizontal wheel, in various and irregular involutions, expanding itself gradually on the lee side, when suddenly a column of the blackest cinders, ashes, and stones would shoot up in the form of a spire, at an angle of from 10 to 20 degrees from a perpendicular line, the angle of inclination being universally to windward; this was rapidly succeeded by a second, third, and fourth shower, each acquiring greater velocity, and overtopping the other, till they had attained an altitude as much above the level of our eye, as the sea was below it. As the impetus with which the columns were severally propelled, diminished, and their ascending motion had nearly ceased, they broke into various branches resembling a group of pines! these again forming themselves into festoons of white feathery smoke, in the most fanciful manner imaginable, intermixed with the finest particles of falling ashes, which at one time assumed the appearance of innumerable plumes of black and white ostrich feathers surmounting each other; at another, that of the light wavy branches of a weeping willow. During these bursts, the most vivid flashes of lightning continually issued from the densest part of the volcano; and the cloud of smoke, now ascending to an altitude much above the highest point to which the ashes were projected, rolled off in large masses of fleecy clouds, gradually expanding themselves before the wind, in a direction nearly horizontal, and drawing up to them a quantity of water-spouts, which formed a most beautiful and striking addition to the general appearance of the scene. In less than half an hour a peak was plainly visible above the water, and about 3 hours from the time of our arrival a complete crater was formed above the water, not less than 20 feet high on the side where the greatest quantity of ashes fell; the diameter of the crater being apparently about 400 or 500 feet. The great eruptions were generally attended with a noise like the continued firing of cannon and musketry intermixed, as also with slight shocks of earthquakes. Now one of the most magnificent bursts took place which we had yet witnessed, accompanied by a very severe shock of an earthquake. In an instant we observed a large portion of the face of the cliff, about 50 yards on our left, falling, which it did with a violent crash. At night the volcano seldom emitted any lightning, but occasionally as much flame as may be seen to issue from the top of a glass-house or foundery chimney. On passing directly under the great cloud of smoke, about 3 or 4 miles distant from the volcano, the decks of the ship were covered with fine black ashes, which fell intermixed with small rain. On opening the volcano clear of the north-west part of the island after dark, on the 16th, we witnessed 1 or 2 eruptions. On the 4th of July, we approached the volcano, and perceived that it was still smoking in many parts, and, upon our reaching the island, found the surf on the beach very high. On landing, we found a narrow beach of black ashes, from which the side of the island rose in general too steep to admit of our ascending; and where we could have clambered up, the mass of matter was much too hot to allow of our proceeding more than a few yards in the ascent. The most extraordinary part was the crater, the mouth of which, on the side facing St. Michael's, was nearly level with the sea. It was filled with water, at that time boiling, and was emptying itself into the sea by a small stream about 6 yards over, and by which I should suppose it was continually filled again at high water. Within the crater I found the complete skeleton of a guard-fish, the bones of which, being perfectly burnt, fell to pieces upon attempting to take them up; and by the account of the inhabitants on the coast of St. Michael's, great numbers of fish had been destroyed during the early part of the eruption, as large quantities, probably suffocated or poisoned, were occasionally found drifted into the small inlets or bays. This island, like other volcanic productions, is composed principally of porous substances, generally burned to complete cinders, with occasional masses of a stone, which I should suppose to be a mixture of iron and limestone.

Sabrina Island has gradually disappeared since the month of October, 1811, leaving an extensive shoal. Smoke was discovered still issuing out of the sea in the month of February, 1812, near the spot where this wonderful phenomenon appeared."

In one province of Persia, for some extent, the ground seems impregnated with inflammable vapours. A reed stuck in the ground, continues to burn like a flambeau; a hole made under the surface instantly becomes a furnace, answering all the purposes of a culinary fire; and the inhabitants make lime by merely burying the stones in the earth.

Captain Beaufort, while surveying Karamania, in Asia Minor, having perceived, during the night, a small, steady light among the hills, by the inhabitants called a *yanar*, or *volcanic light*, curiosity led him to visit it. In the corner of a ruined building, was a wall undermined by an aperture of 3 feet diameter, like the mouth of an oven, from which the flame issued, with intense heat, but without smoke; and though several small lumps of caked soot were detached from the neck of the opening, the walls were scarcely discoloured. Trees, brushwood, and weeds, grew around this little crater; a small stream trickled down the hill in its vicinity; and the ground did not appear affected by its heat more than a few yards distance. No volcanic productions were perceived; but lower down the hill, was another aperture, which had apparently been the vent of a similar flame. It was never accompanied by earthquakes or noises; and did not eject either stones, smoke, or noxious vapours; but its brilliant and perpetual flame could not be quenched by any quantity of water; and at this flame the shepherds often dressed their food.

This phenomenon appears to have existed for many ages, and Captain Beaufort is persuaded it is the spot alluded to by Pliny: "Mount Chimæra, near Phaselis, emits an unceasing flame, which burns day and night." At a short distance is Takhtalu, whose naked summit rises, insulated, 7800 feet above the level of the sea, and on which, in August, a few streaks of snow were discernible; but many distant mountains were white nearly a fourth down their sides. Hence the elevation of this part of Mount Taurus is supposed about 10,000 feet, equal to that of Mount Etna.

Sir William Hamilton has thrown great light on the history of volcanos. In various letters on this curious and interesting subject, he has demonstrated that these formidable phenomena serve as spiracles, or tunnels, to those subterraneous fires which would otherwise render the dreadful effects of earthquakes more dreadful still

> The dread volcano ministers to good;
> Its smother'd flames might undermine the world:
> Loud Etnas fulminate in love to man. YOUNG.

He has also demonstrated, that many of the revolutions in the face of the globe have been effected by absolute chemical processes, carried on by Nature, on a more wonderful and extensive scale than the puny efforts of human art.

"The gulfs of Gaeta and Terracina (says Sir William) may, in the course of time, become another Campo Felice: for the rich and fertile plain so called, which extends from the bay of Naples to the Appenines, behind Caserta and Capua, has evidently been entirely formed by a succession of such volcanic eruptions. Vesuvius, the Solfaterra, and the high volcanic grounds, on the greater part of which the city of Naples is built, were once probably islands; and we may conceive the islands of Procita, Ischia, Ventotiene, Palmarole, Ponza, and Zannone, to be the outline of a new portion of land, intended by Nature to be added to the neighbouring continent; and the Lipari islands (all of which are volcanic) may be looked upon in the same light, with respect to a future intended addition to the island of Sicily. Many new discoveries have been made of late years, particularly in the south seas, of islands which owe their birth to volcanic explosions; and some, indeed, where the volcanic fire still operates. It is reasonable to suppose, that upon further examination, most of the elevated islands, at a considerable distance from continents, would be found to have a volcanic origin; as the low and flat islands appear in general to have been formed of the spoils of sea productions, such as corals, madrepores, &c. That which was one day in a calcareous state, and formed by an insect in the sea, becomes vitrefied in another, by the action of the volcanic fire, and the addition of some natural ingredients, such as sea salts and weeds; and is again transformed to a pure clay, by another curious process of Nature. The naturalist may indeed decide as to the present quality of any natural production, but it would be presumptuous in him to decide as to its former states. As far as I can judge in this curious country, active Nature seems to be constantly employed in composing, decomposing, and recomposing; but surely for all-wise and benevolent purposes, though on a scale, perhaps, too great and extensive for our limited comprehension."

In October, 1822, two eruptions of Galong Goening took place. The plain of Singapama was covered with mud, mixed with burning sulphur; and it is said, that 20 kampongs have been destroyed, and 1000 persons killed.

LECTURE XXIV.

EARTHQUAKES.

How greatly terrible, how dark and deep
The purposes of Heaven! At once o'erthrown,
White age and youth, the guilty and the just,
(Oh, seemingly severe!) promiscuous fall.
Reason, whose daring eye in vain explores
The fearful providence, confused, subdued
To silence and amazement, with due praise
Acknowledges th' Almighty, and adores
His will unerring, wisest, justest, best!

Towers, temples, palaces,
Flung from their deep foundations, roof on roof
Crush'd horrible, and pile on pile o'erturn'd.
Fall total. MALLET

The globe around earth's hollow surface shakes,
And is the ceiling of her sleeping sons.
O'er devastation we blind revels keep;
Whose buried towns support the dancer's heel. YOUNG.

EARTHQUAKES are unquestionably the most dreadful of the phenomena of nature; and are not confined to those countries which, from the influence of climate, their vicinity to volcanic mountains, or any other similar cause, have been considered as more particularly subject to them; their effects have often been felt in the British isles, although not in so extensive and calamitous a degree.

The most remarkable earthquakes of ancient times are described by Pliny, in his Natural History. Among the most extensive and destructive of these was one by which thirteen cities in Asia Minor were swallowed up in one night*. Another, which succeeded, shook the

In Blair's Grammar of Philosophy it is suggested, that cities are chiefly affected, because they contain the greatest quantities of conducting metallic bodies; so also with rivers.

greater part of Italy. But the most extraordinary one, described by him, happened during the consulate of Lucius Marcus and Sextus Julius, in the Roman province of Mutina. He relates, that two mountains felt so tremendous a shock, that they seemed to approach and retire, with a most dreadful noise. They, at the same time, and in the middle of the day, cast forth fire and smoke, to the dismay of the astonished spectators. By this shocks everal towns were destroyed, and all the animals in their vicinity killed. During the reign of Trajan, the city of Antioch was, together with a great part of the adjacent country, destroyed by an earthquake; and about 300 years after, during the reign of Justinian, it was again destroyed, with the loss of 40,000 of its inhabitants. Lastly, after an interval of 60 years, that ill-fated city was a third time overwhelmed, with a loss of 60,000 souls.

The earthquake which happened at Rhodes, upwards of 200 years before the Christian era, threw down the famous Colossus, together with the arsenal, and a great part of the walls of the city. In the year 1182, the greater part of the cities of Syria, and of the kingdom of Jerusalem, were destroyed by a similar catastrophe; and in 1594, the Italian writers describe an earthquake at Puteoli, which occasioned the sea to retire 200 yards from its former bed.

The dreadful earthquake which happened in Calabria, in 1638, is described by Father Kircher, who was at that time on his way to Sicily, to visit Mount Etna. In approaching the gulf of Charybdis, it appeared to whirl round, in such a manner as to form a vast hollow, verging to a point in the centre. On looking towards Etna, it was seen to emit large volumes of smoke, of a mountainous size, which entirely covered the whole island, and obscured from his view the very shores. This, together with the dreadful noise, and the sulphureous stench which was strongly perceptible, filled him with apprehensions that a still more dreadful calamity was impending. The sea was agitated, covered with bubbles, and had altogether a very unusual appearance. The father had scarcely reached the Jesuits' college, when he was stunned with a horrid sound, resembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs cracking. The tract on which he stood seemed to vibrate, as if he had been in the scale of a balance which still continued to waver. The motion soon becoming more violent, he was thrown prostrate on the ground. The universal ruin around him now redoubled his amazement: the crash of falling houses, the tottering of towers, and the groans of the dying, all contributed to excite emotions of terror and despair.

The great earthquake of 1755 extended over a tract of at least 4,000,000 of square miles. It appears to have originated beneath the Atlantic Ocean, the waves of which received almost as violent a concussion as the land. Its effects were even extended to the waters, in many places where the shocks were not perceptible. It pervaded the greater portions of the continents of Europe, Africa, and America; but its extreme violence was exercised on the south-western parts of the former.

Lisbon, the Portuguese capital, had already suffered greatly from an earthquake in 1531; and, since the calamity about to be described, has had three such visitations, in 1761, 1765, and 1772, which were not, however, attended by equally disastrous consequences. In the present instance, it had been remarked that, since the commencement of the year 1750, less rain had fallen than had been known in the memory of the oldest of the inhabitants, unless during the spring preceding the calamitous event. The summer had been unusually cool; and the weather fine and clear for the last 40 days. At length, on the 1st of November, about 40 minutes past 9 in the morning, a most violent shock of an earthquake was felt: its duration did not exceed 6 seconds; but so powerful was the concussion, that it overthrew every church and convent in the city, together with the royal palace, and the magnificent opera-house adjoining to it; in short, not any building of consequence escaped. About one-fourth of the dwelling houses were thrown down; and, at a moderate computation, 30,000 individuals perished.

The first shock was extremely short, but was quickly succeeded by 2 others; and the whole, generally described as a single shock, lasted from 5 to 7 minutes. About 2 hours after, fires broke out in 3 different parts of the city; and this new calamity prevented the digging out of the immense riches concealed beneath the ruins. From a perfect calm, a fresh gale immediately after sprang up, and occasioned the fire to rage with such fury, that in the space of 3 days the city was nearly reduced to ashes. Every element seemed to conspire towards its destruction; for, soon after the shock, which happened near high water, the tide rose in an instant 40 feet, and at the castle of Belem, which defends the entrance of the harbour, 50 feet higher than had ever been known. Had it not subsided as suddenly, the whole city would have been submerged. A large new quay sunk to an unfathomable depth, with several hundreds of persons, not one of the bodies of whom was afterwards found. Before the sea thus came rolling in like a mountain the bar was seen dry from the shore.

The great shock was succeeded about noon by another, when the walls of several houses which were still standing, were seen to open from the top to the bottom, more than a fourth of a yard, and afterwards to close again so exactly as not to leave any signs of injury. Between the 1st and the 8th of November, 22 shocks were reckoned.

This earthquake was also felt at Oporto, Cadiz, and other parts of Europe, and equally severe in Africa. A great part of the city of Algiers was destroyed. In many places of Germany the effects of this earthquake were very perceptible; but in Holland, the agitations were still more remarkable. The agitation of the waters was also perceived in various parts of Great Britain and Ireland. At Cobham, in Surrey; Dunstall, in Suffolk; Earsy Court, in Berkshire; Eaton Bridge, Kent; and many other places, the waters were variously agitated. At Shireburn Castle, Oxfordshire, a little after 10 in the morning, a very strange motion was observed in the water of a moat which encompasses the building. Similar instances occurred at Loch Lomond and Loch Ness, in Scotland. At Kinsale, in Ireland; and all along the coast to the westward, many similar phenomena were observed. Shocks were also perceived in several parts of France, as at Bayonne, Bourdeaux, and Lyons; and commotions of the waters were observed at Angoulesme, Belleville, Havre de Grace, &c. but not attended with any remarkable circumstances.

At sea the shocks of this earthquake were felt most violently. Among other catastrophes, the captain of the Nancy frigate, off St. Lucar, felt his ship so violently shaken, that he thought she had struck the ground; but, on heaving the lead, found she was in a great depth of water.

The earthquakes in Sicily, and the two Calabrias, began on the 5th of February, 1783, and continued until the latter end of the May following, doing infinite damage, and exhibiting at Messina, in the parts of Sicily nearest to the continent, and in the two Calabrias, a variety of phenomena. The earth was in a constant tremor, and its motions were various, being either vertical, or whirling round, horizontal, or oscillatory, that is, by pulsations or beatings, from the bottom upwards. There were many openings and cracks in the earth; and several hills had been lowered, while others were quite level. In the plains, the chasms were so deep, that many roads were rendered impassable. Huge mountains were severed, and portions of them driven into the valleys, which were thus filled up. The total amount of the mortality occasioned by these earthquakes, in Sicily and the two Calabrias, was, agreeably to the official returns, 32,367; but Sir William Hamilton thought it still greater, and carries his estimate to 40,000, including foreigners.

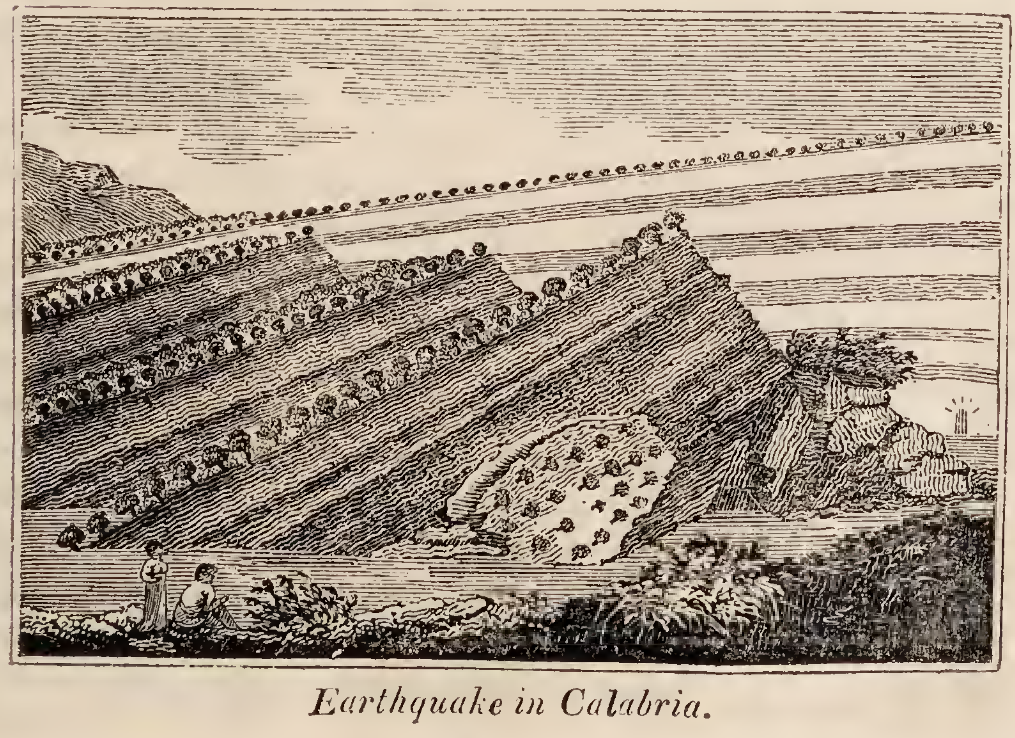
The shocks felt since the commencement of these formidable earthquakes, amounted to several hundreds; and amongst the most violent may be reckoned the one which happened on the 28th of March. It affected most of the higher parts of Upper Calabria, and the inferior part of Lower Calabria, being equally tremendous with the first. Indeed these shocks were the only ones sensibly felt in the capital, Naples. With relation to the former, 2 singular phenomena are recorded: at the distance of about 3 miles from the ruined city of Oppido, in Upper Calabria, was a hill, having a sandy and clayey soil, nearly 400 feet in height, and nearly 900 feet in circumference at its base. This hill is said to have been carried to the distance of about 4 miles from the spot where it stood, into a plain called Campo di Bassano. At the same time, the hill on which the city of Oppido stood, and which extended about 3 miles, divided into 2 parts: being situated between 2 rivers, its ruins filled up the valley, and stopped their course, forming 2 large lakes, which augmented daily.

Sir William Hamilton, from the limited bounoaries of these earthquakes, was persuaded that they were caused by some great operation of nature, of a volcanic kind. To ascertain this, he began his tour by visiting the parts of the coasts of the two Calabrias which had suffered most from this severe visitation. He every where came to ruined towns and houses, the inhabitants of which were in sheds, many of them built on such insalubrious spots that an epidemy had ensued. These unfortunate people agreed that every shock they had felt, seemed to come, with a rumbling noise, from the westward, beginning usually with the horizontal motion, and ending with the vortical, or whirling motion, which last had ruined most of the buildings. It had also been generally observed, that, before a shock, the clouds seemed to be fixed and motionless; and that, after a heavy shower of rain, a shock quickly followed. By the violence of some of the shocks, many persons had been thrown down: and several of the peasants described the motion of the earth as so violent, that the tops of the largest trees almost touched the ground from side to side. It had been stated, in the reports made to government, that 2 tenements, named Macini and Vaticano, had, by the effect of the earthquake, changed their situation. In this fact Sir William agrees, and accounts for it in the following manner:—They were situated in a valley surrounded by high grounds, and the surface of the earth, which had been removed, had probably been long undermined by the little rivulets which flow from the mountains, and were in full view on the bare spot the tenements had deserted. He conjectures, besides, that, the earthquake having opened some depositions of rain-water in the clayey hills which surround the valley, the water, mixing with the loose soil, and taking its course suddenly through the undermined surface, had lifted it up, together with the large olive and mulberry trees, and a thatched cottage, floating the entire piece of ground, with all its vegetation, about a mile down the valley, where he saw it, with most of the trees erect. (See *the Engraving.*) These two tenements occupied a space of ground about a mile in length, and half a mile in breadth. There were in the vicinity several deep cracks in the earth, not one of which was then more than a foot in breadth; but Sir William was credibly assured, that, during the earthquake, one had opened wide, and had swallowed up an ox, and nearly 100 goats.

The force of the earthquakes, although very violent at Messina, and at Reggio on the opposite side of the strait, was not to be compared to that which was felt in the plain. In the former city the mortality did not exceed 700, of a population of 30,000. Sir William concludes by remarking, that the local earthquakes here described, appear to have been caused by the same kind of matter as that which gave birth to the Æolian or Lipari islands. He conjectures that an opening may have been made at the bottom of the sea, most probably between Stromboli and Upper Calabria; for from that quarter, it was on all hands agreed, the subterraneous noises seemed to proceed. He adds, that the foundation of a new island, or volcano, may have been laid, although it may be ages, which to Nature are but moments, before it shall be completed, and appear above the surface of the sea.

Count Francesco Ippolito, in speaking of the last

Grotto del Cane.



Earthquake in Calabria.

great shock of the 28th of March, as it affected the Calabrian territory, is persuaded that it arose from an internal fire in the bowels of the earth, as it took place precisely in the mountains which cross the neck of the peninsula, formed by the two rivers, the Lameto and the Corace, the former of which flows into the Gulf of St. Euphemia, and the latter into the Ionian Sea. All the phenomena it displayed, made this evident.

South America has been at all times very subject to earthquakes; and it is remarkable, that the city of Lima, the capital of Peru, situated in about 12 degrees of south latitude, although scarcely ever visited by tempests, and equally unacquainted with rain as with thunder and lightning, has been singularly exposed to their fury.

Among the most tremendous earthquakes with which the Peruvian capital has been visited, may be reckoned that which happened on the 28th of October, 1687. The first shock was at 4 in the morning, when several of the finest public buildings and houses were destroyed, with the loss of many lives. During the second shock the sea retired considerably, and then returned in mountainous waves, entirely overwhelming Callao, the sea-port of Lima, distant 5 miles, as well as the adjacent country, together with the wretched inhabitants. From that time 6 other earthquakes were felt at Lima, prior to that of 1746, which likewise happened on the 28th of October, at half past 10 at night. At length the horrible effects of the first shock ceased; but the tranquillity was of short duration, the concussions swiftly succeeding each other. The sea, as is usual on such occasions, receding to a considerable distance, returned in mountainous waves, foaming with the violence of the agitation, and suddenly buried Callao and the neighbouring country in its flood. This terrible inundation extended, as well as the earthquake, to other parts of the coast, and several towns underwent the fate of Lima. The number of persons who perished in that capital, within 2 days after the earthquake commenced, on an estimate of the bodies found, amounted to 1300.

The earthquake of Jamaica, in 1692, was one of the most dreadful history has had to record. In the space of 2 minutes it destroyed the town of Port Royal, and sunk the houses in a gulf 40 fathoms deep. It was attended with a hollow rumbling noise, like that of thunder. In less than a minute, the greater part of the houses on one side of the streets, were, with their inhabitants, sunk beneath the water, while those on the other side were thrown into heaps, the sandy soil on which they were built rising like the waves of the sea, and suddenly overthrowing them on its subsidence. The fissures in the earth were in some places so great, that one of the streets appeared of more than twice its original breadth. In many places the earth opened and closed again; and this agitation continued for a considerable time. Several hundreds of these openings were to be seen at the same moment: in some of them the wretched inhabitants were swallowed up; while in others, the earth, suddenly closing, caught them by the middle, and thus crushed them to death. Other openings, still more dreadful, swallowed up entire streets; while others, again, spouted up cataracts of water, drowning those whom the earthquake had spared.

In describing the great earthquake at Cumana, M. Humboldt says, that from October 28, to the 3d of November, a reddish fog was thicker than it had yet been. The heat of the night seemed stifling, though the thermometer rose only to 91°. The breeze, which generally cooled the air from eight or nine o'clock in the evening, was no longer felt. The atmosphere appeared as if it were on fire. The ground, parched and dusty, was cracked on every side. On the 4th of November, about two in the afternoon, large clouds of an extraordinary blackness, enveloped the high mountains of the Brigantine and Tataraqual. They extended, by degrees, as far as the zenith. About four in the afternoon, thunder was heard, over our heads, but at an immense height, without rolling, and with a hoarse and often interrupted sound. At the moment of the strongest electric explosion, at 4h. 12m. there were two shocks of an earthquake, which followed at fifteen seconds distance from each other. The people in the streets filled the air with their cries. M. Bonpland, who was leaning over a table, examining plants, was almost thrown on the floor. I felt this shock very strongly, though I was lying in a hammock. Its direction was from north to south, which is rare at Cumana. Slaves, who were drawing water from a well, more than eighteen or twenty feet deep, near the river Manzanares, heard a noise like the explosion of a strong charge of gunpowder. The noise seemed to come from the bottom of the well. About nine in the evening there was another shock, attended with a subterraneous noise. The earthquake of the 4th of November, the first I had felt, made so much the more lively an impression on me, as it was accompanied with remarkable meteorological variations. It was, moreover, a real lifting-up, and not a shock by undulations. I did not then imagine, that, after a long abode on the table-lands of Quito, and the coasts of Peru, I should become almost as familiar with the abrupt movements of the ground, as we are in Europe with the noise of thunder. We did not think of rising at night, in the city of Quito, when subterraneous rumblings (*bramidos*), which seem always to come from the volcano of Pichincha, announced (two or three, and sometimes seven or eight minutes before) the shock, the force of which is seldom in proportion to the intensity of the noise. In 1784, the inhabitants of Mexico were accustomed to hear the thunder roll beneath their feet, as it is heard by us in the region of the clouds.

In 1812, Venezuela was visited by one of these tremendous earthquakes. During 1 minute and 15 seconds the earth was convulsed in every direction, and nearly 20,000 persons fell victims. The towns of Caraccas, La Guayra, Mayquetia, Merida, and Sanfelipe, were totally destroyed. Barquisimeto, Valencia, La Vittoria, and others, suffered considerably.

In 1822, the tremendous earthquake took place in Syria, by which whole cities were destroyed, and 20,000 persons perished in a few seconds, and in the same year a series of earthquakes took place in Chili, by which the town of Valparaiso suffered considerably.

Dr. Grainger, in his beautiful poem, the Sugar Cane, gives the following picturesque description of an earthquake in the West Indies, where that phenomenon is very frequent.

Earthquakes, Nature's agonizing pangs,
Oft shake th' astonied isles; the solfaterre
Or sends forth thick, blue, suffocating steams;
Or shoots to temporary flame. A din,
Wild, through the mountain's quivering rocky caves,
Like the dread crash of tumbling planets, roars.
When tremble thus the pillars of the globe,
Like the tall coco by the fierce North blown,
Can the poor, brittle tenements of man
Withstand the dread convulsion? Their dear homes
(Which shaking, tottering, crashing, bursting, fall)
The boldest fly; and on the open plain
Appall'd, in agony, the moment wait,
When, with disrupture vast, the waving earth
Shall whelm them in her sea-disgorging womb.
Nor less affrighted are the bestial kind.
The bold steed quivers in each panting vein,
And staggers, bath'd in deluges of sweat:
The lowing herds forsake their grassy food,
And send forth frighted, woful, hollow sounds:
The dog, thy trusty centinel of night,

Deserts his post assign'd, and piteous howls.
Wide ocean feels ——
The mountain waves, passing their custom'd bounds,
Make direful, loud incursions on the land,
All over-whelming: sudden they retreat,
With their whole troubled waters; but, anon,
Sudden return, with louder, mightier force;
(The black rocks whiten, the vext shores resound;)
And yet, more rapid, distant they retire.
Vast coruscations lighten all the sky,
With volumed flames; while Thunder's awful voice,
From forth his shrine, by night and horror girt,
Astounds the guilty, and appals the good.

Some naturalists have ascribed earthquakes to water, others to fire, and others, again, to air; each of these powerful agents being supposed to operate in the bowels of the earth, which they assert to abound every where with huge subterraneous caverns, veins, and canals, some filled with water, others with gaseous exhalations, and others replete with various substances, such as nitre, sulphur, bitumen, and vitriol. Dr. Lister ascribes earthquakes, as well as thunder and lightning, to the inflammable breath of the pyrites, a substantial sulphur, capable of spontaneous combustion. Dr. Woodward thinks, that the subterraneous fire, which continually raises the water from the abyss, or great reservoir, in the centre of the earth, for the supply of dew, rain, springs, and rivers, being diverted from its ordinary course by some accidental obstruction in the pores through which it used to ascend to the surface, becomes, by such means, preternaturally assembled, in a greater quantity than usual, in one place, and thus causes a rarefaction and intumescence of the water of the abyss, throwing it into greater commotions, and at the same time making the like effort on the earth, which, being expanded on the surface of the abyss, occasions an earthquake. Mr. Mitchell supposes these phenomena to be occasioned by subterraneous fires, which, if a large quantity of water be let loose on them suddenly, may produce a vapour, the quantity and elastic force of which may fully suffice for the purpose. M. Amontons endeavours to prove that, on the principle of the experiments made on the weight and spring of the air, a moderate degree of heat may bring that element into a state capable of causing earthquakes.

Modern electrical discoveries have thrown much light on this subject. Dr. Stukeley strenuously denies that earthquakes are to be ascribed to subterraneous winds, fires, or vapours; and thinks that there is not any evidence of the cavernous structure of the earth, which such an hypothesis requires. Subterraneous vapours, he thinks, are altogether inadequate to the effects produced by earthquakes, more particularly in cases where the shock is of considerable extent: for a subterraneous power, capable of moving a surface of earth only 30 miles in diameter, must be lodged at least 15 or 20 miles below the surface, and move an inverted cone of solid earth, whose basis is 30 miles in diameter, and axis 15 or 20 miles, which he thinks absolutely impossible. How much more inconceivable is it, then, that any such power could have produced the earthquake of 1755, which was felt in various parts of Europe and Africa, and in the Atlantic ocean; or that in Asia Minor, in the 17th year of the Christian era, which destroyed 13 great cities in one night, and shook a mass of earth 300 miles in diameter. To effect this, the moving power, supposing it to have been internal fire or vapour, must have been lodged 200 miles beneath the surface of the earth! Besides, in earthquakes, the effect is instantaneous; wherefore, as the operation of elastic vapour, and its discharge, must be gradual, and require a long space of time; and if these be owing to explosions, they must alter the surface of the country where they happen, destroy the fountains and springs, and change the course of its rivers,—results which are contradicted by history and observation.

To these, and other considerations, the Doctor adds, that the strokes which ships receive during an earthquake, must be occasioned by something which can communicate motion with much greater velocity than any heaving of the earth under the sea, caused by the elasticity of generated vapours, which would merely produce a gradual swell, and not such an impulsion of the water as resembles a violent blow on the bottom of a ship, or its striking on a rock. Hence he deems the common hypothesis insufficient, and adduces several reasons to show that earthquakes are in reality electric shocks. To confirm this opinion, he notices, among other phenomena, either preceding or attending earthquakes, that the weather is usually dry and warm for some time before they happen, and that the surface of the ground is thus previously prepared for that kind of electrical vibration in which they consist; while, at the same time, in several places where they have occurred, the internal parts, at a small depth beneath the surface, were moist and boggy. Hence he infers, that they reach very little beneath the surface. That the southern regions are more subject to earthquakes than the northern, he thinks is owing to the greater warmth and dryness of the earth and air, which are qualities so necessary to electricity. The frequent and singular appearances of boreal and austral *auroræ*, and the variety of meteors by which earthquakes are preceded, indicate an electrical state of the atmosphere.

The theory of M. de St. Lazare differs from the above hypothesis, as to the electrical cause. It ascribes the production of earthquakes to the interruption of the equilibrium between the electrical matter diffused in the atmosphere, and that which belongs to the mass of our globe, and pervades its bowels. If the electrical fluid should be superabundant, as may happen from a variety of causes, its current, by the laws of motion peculiar to fluids, is carried towards those places where it is in a similar quantity; and thus it will sometimes pass from the internal parts of the globe into the atmosphere. This happening, if the equilibrium be re-established without difficulty, the current merely produces the effect of what M. de St. Lazare calls ascending thunder; but if this re-establishment be opposed by considerable and multiplied obstacles, the consequence is then an earthquake, the violence and extent of which are in exact proportion to the degree of interruption of the equilibrium, the depth of the electric matter, and the obstacles which are to be surmounted. If the electric furnace be sufficiently large and deep to give rise to the formation of a conduit or issue, the production of a volcano will follow, its successive irruptions being, according to him, nothing more in reality than electric repulsions of the substances contained in the bowels of the earth. From this reasoning he endeavours to deduce the practicability of forming a counter-earthquake, and a counter-volcano, by means of certain electrical conductors, which he describes, so as to prevent these convulsions in the bowels of the earth.

The opinion of Signior Beccaria is nearly similar: and from his hypothesis and that of Dr. Stukeley, the celebrated Priestley has endeavoured to form one still more general and more feasible. He supposes the electric fluid to be in some mode or other accumulated on one part of the surface of the earth, and, on account of the dryness of the season, not to diffuse itself readily: it may thus, as Beccaria conjectures, force its way into the higher regions of the air, forming clouds out of the vapours which float in the atmosphere, and may occasion a sudden shower, which may further promote its progress. The whole surface being thus unloaded, will, like any other conducting substance, receive a concussion, either on parting with, or on receiving, any quantity of the electric fluid. The rushing noise will likewise sweep over the whole extent of the country; and, on this supposition also, the fluid, in its discharge from the surface of the earth, will naturally follow the course of the rivers, and will take the advantage of any eminences to facilitate its ascent into the higher regions of the air.

Such are the arguments in favour of the electrical hypothesis; but, since it has been supported with so much ability, an ingenious writer, Whitehurst, in his Inquiry into the original State and Formation of the Earth, contends, that subterraneous fire, and the steam generated from it, are the true and real causes of earthquakes. When, he observes, it is considered that the expansive force of some steam is to that of gunpowder as 28 to 1, it may be conceded that this expansive force, and the elasticity of steam, are in every way capable of producing the stupendous effects attributed to these phenomena.

Among the most striking phenomena of earthquakes, which present a fearful assemblage of the combined effects of air, earth, fire, and water, in a state of unrestrained contention, may be noticed the following. Before the percussion a rumbling sound is heard, proceeding either from the air, or from fire, or, perhaps, from both in conjunction, forcing their way through the chasms of the earth, and endeavouring to liberate themselves: this, as has been seen, likewise happens in volcanic eruptions. Secondly, a violent agitation or heaving of the sea, sometimes preceding, and sometimes following, the shock. Thirdly, a spouting-up of the waters to a great height—a phenomenon which is common to earthquakes and volcanos. Fourthly, a rocking of the earth, and, occasionally, what may be termed a perpendicular rebounding: this diversity has been supposed by some naturalists to arise chiefly from the situation of the place, relatively to the subterraneous fire, which, when immediately beneath, causes the earth to rise, and when at a distance, to rock. Fifthly, earthquakes are sometimes observed to travel onward, so as to be felt in different countries at different hours of the same day. This may be accounted for by the violent shock given to the earth at one place, and communicated progressively by an undulatory motion, successively affecting different regions as it passes along, in the same way as the blow given by a stone thrown into a lake, is not perceived at the shore until some time after the first concussion. Sixthly, the shock is sometimes instantaneous, like the explosion of gunpowder, and sometimes tremulous, lasting for several minutes. The nearer to the observer the place where the shock is first given, the more instantaneous and simple it appears; while, at a greater distance, the earth seems to redouble the first blow, with a sort of vibratory continuation. Lastly, as the waters have in general so great a share in the production of earthquakes, it is not surprising that they should generally follow the breaches made by the force of fire, and appear in the great chasms opened in the earth.

The following views, in regard to the cause of earthquakes, have been published by Sir Richard Phillips. Inasmuch as he considers that there are no subterraneous fires, at least at any depth in the earth, heat, according to him, being mere atomic motion, and flame the evolution of hydrogen by the fixation of oxygen, so subterraneous fires have no concern in producing these phenomena: moreover, says he, the required depth to affect such large surfaces would be beneath the primary formations, where the substances do not exist whose combination produces sufficient atomic motion, or heat. Again, as Sir Richard denies the existence of any electric fluid, so all the pretended accumulations of such fluid, must be fabulous. The circumstance, however, of ships receiving shocks at sea, such as could arise from no mechanical impulsion, and the fact that electrical phenomena are propagated through water, are conclusive, to his mind, that the cause is electrical, and of the species called galvanic. He thinks the theory of Dr. Stukeley perfectly satisfactory, by substituting the word galvanism for the word electrical, taken in its common meaning. We have in another place given Sir Richard's theory of Electricity and Galvanism, and we have only to conceive, with Dr. Stukeley, that at the time of an earthquake the strata of the earth form a galvanic series, which, extending and acting over a large surface, would affect the strata in the abrupt manner of an earthquake, and produce effects laterally, to a much greater distance. In a word, Sir Richard calls a thunder-storm a natural exhibition of ordinary electricity, and an earthquake a natural exhibition of the voltaic pile, and he remarks that the obvious remedy against both, would, in the first case, be to erect metallic conductors, from the earth to the region of the clouds, and, in the case of earthquakes, to drive metallic conductors through the strata which form the galvanic combination. Such are the general causes of earthquakes, but during eruptions of volcanos, the earth trembles, owing to the vibration of the explosions, just as it does during a battle, when numerous artillery are employed, and earthquakes of this description must be considered as mere mechanical impulses.

The focus of subterraneous fires is, therefore, at a moderate depth, and they only communicate on some points. In fact, how could they be formed in the bowels of the earth, when the air cannot reach them, and the granitic base, so close and homogeneous, opposes circulation? Still the globe experiences commotions, which are seen to shake it thoroughly; countries where no traces of volcanos have been ever perceived, feel earthquakes. Such is Switzerland, which has been always subject to this scourge; and that of December 9, 1755, is remembered with horror, as it shook the mass of the Alps and Pyrenees, and was felt through the south of Europe.

LECTURE XXV.

ON COALS.

Hence sable coal his massy couch extends,
And stars of gold the sparkling pyrite blends. DARWIN.

THE coal stratum, which next claims our attention, is, perhaps, of greater importance and value to us, than any which we have hitherto considered; inasmuch as it affords some of the most essential domestic enjoyments of civilized life; for, peopled and cultivated as England is, and therefore possessing but few, and small forests, the comforts of its inhabitants are greatly augmented by, and may be said, in a great measure, to depend upon, its inexhaustible deposits of coal.

Coal, in greater or less quantities, is found in most countries, at various elevations, (but almost all the *great* deposits are in low situations) in beds lying over each other, of various thicknesses, having between them, beds of stony or earthy matters; and it is remarkable, that though these beds of coal are nearly horizontal, they are never quite so, but sink near the middle, so that a section would give the idea of a cup, or basin.

Coal is found at various degrees of elevation above the sea. At Dee Hill, in Shropshire, there are coals working, 1800 feet in height; and at Richmond, in Yorkshire, nearly 2200 feet; but, in both these instances, the bed of coal is nearly vertical, owing to the rising up of the hills, supporting their loftiest terminations, or to the subsidence of the surrounding country. There is a coal deposit, in the immediate vicinity of the great silver mine of Pasco, in Peru, which is about 3 miles above the level of the sea. This coal is now employed in the working of the steam engines, sent out from this country, to drain that, and the neighbouring mines, which, previously, had been almost abandoned, owing to the prevalence of water, even at that great elevation. Coal is found also in *North* America, even in the inhospitable frozen deserts visited by Capt. Parry. In New Holland, China, Japan, and most countries of Europe, it is found in abundance.

It is generally considered that there are three formations of coal, the *newest*, the *floetz trap*, and the *independent*. The newest coal formation occurs in alluvial soils. In this, the strata of coal are not parallel to each other, and the earthy strata that are found between, consist of sand, clay, and gravel.

A remarkable deposit of this kind is found at Bovey Heathfield, near Exeter; it is a brown coal, or compact carbonized wood. The thickness of the whole deposit, including the beds of clay with which it is interstratified, is 70 feet. There are six beds of coal, and as many of brownish clay. The upper bed varies from 18 inches to 4 feet in thickness, and each succeeding bed is thicker; so that the lower most is 16 feet thick, reposing on a bed of greenish sand, about 17 feet thick, which rests on a bed of hard, close clay; this has been bored into without finding coal. The whole deposit extends about a mile, and dips, to the south, 10 inches in a yard. The coal is dug out, for fuel, from an extensive, open mine, the descent to which is so easy, that horses are employed to carry up the produce.

The coal in the centre of the lowest bed, is of a black colour, nearly as heavy as pit-coal, makes a strong and durable fire, and is, in all respects, a perfect mineral coal. The other beds are more of a chocolate colour, not so heavy, and with more the appearance of wood, and lie in pieces, crossing each other, in all directions, and which, when split, is called board coal. Some pieces are found, which have the knots of wood in them, in one part, while another portion of the same piece is converted into perfect mineral coal. So that Nature is, in this instance, seen in the very act of forming mineral coal, from vegetable matter.

Various speculations have been entertained with regard to the origin of Bovey coal. But, when we consider that the low land on which it is found is almost surrounded by a range of hills, that lie at the feet of Dartmoor and Haldon, and has every appearance of having once been a morass, and that the neighbouring high land exhibits traces of numerous stumps of trees, of immense size, which, from their organization, appear to have belonged to the fir tribe, it will not appear very difficult to discover the origin of Bovey coal.

The clay near the coal is bituminous, and contains lumps, of a bright yellow colour, extremely light; they burn like sealing-wax, and emit a very agreeable aromatic scent. They appear to be the resinous product of trees which have undergone some chemical process, by being buried in the earth for many ages. It is remarkable, that amber is found, under similar circumstances, in Prussia. There, under a stratum of clay and sand, is found a bed of trees, 40 or 50 feet thick, in a half decomposed state, impregnated with iron pyrites and bitumen. In this stratum are occasionally found pieces of wood, penetrated by veins of amber. The half-mineralized wood rests upon a bed of pyrites, among which are frequently found masses of amber, adhering, by one side, to the trees. The miners who are employed to procure the amber, sink through the trees, and then drive three drifts along the under surface, where the amber is found in greatest quantity. The similarity of this deposit to the Bovey coal, warrants the expectation, that this subterranean forest will, in future ages, yield important services to man in the shape of coal. A similar deposit is now forming on the Missouri, in North America, where the trunks of trees floated down the stream, have become packed together, forming a bridge, not less than 3 miles in length, and which is continually increasing. This may, to future generations, furnish an example of the newest coal formation.

The coal formation next in point of age, is that to which Werner has given the name *newest floetz trap*, the result, as he conceives, of deluges. It is also occasionally found in rocks of sandstone and lime, which accompany the independent coal formation. In this the coal is generally covered with clay or basalt, in which are found neither vegetable impressions nor animal remains. The strata are not so numerous as in that formation called independent; nor are they so perfectly parallel with each other. The chief collieries of France and Scotland are of this description. They yield, principally, the varieties called pitch coal and moor coal, not often slate coal.

The *independent* coal formation is that of most importance; it is so called, because the individual depositions, or beds, are not connected, but independent of each other.

This formation consists of remarkably parallel strata of coal, covered by strata of indurated clay, called shale, containing the impressions of vegetables, and sometimes the remains of shell fish. This shale is never found in either of the two coal formations before described, but it is peculiar to the independent, and always accompanies it.

The coals of England chiefly belong to this class, and are scattered over a considerable extent of country. The most southern is a small one, lying at the N. E. termination of the Mendip Hills, in Somersetshire. Two or three small patches are found to the north of that point; then comes the more extensive deposit of Ringswood, and Micklewood, near Bristol; to the north-west of which, and on the other side of the Severn, is found the coal of the Forest of Dean.

Coal again occurs, near Stourport, in Worcestershire, whence it ranges in a direction nearly north, and with little interruption, to Chester, and beyond it, on both banks of the Dee.

An immense deposit, of which the most southern point is near Nottingham, ranges through Derbyshire, Yorkshire, Durham, and Northumberland, quite to the Tweed. In this long range, the coal is not absolutely connected, but the interruptions are not considerable. Abundance is again found at Whitehaven, on the north-western coast of England. Besides the foregoing, are many small insular patches, on the north-east and north-west of Birmingham. In Wales there is also a large deposit, on its southern coast.

The coal of England and Wales is found mostly lying above mountain limestone, between which and the coal, are some interposed beds of sandstone, or grit, containing rounded masses of quartz. This is occasionally of a character which admits of its being used for millstones, and has therefore been denominated the millstone grit. Mowcop Hill, near the Staffordshire potteries, furnishes a good example of this rock; the grains are very large in some parts, and thin veins of barytes traverse it.

The rocks which are interstratified with coal are, sandstone, slaty micaceous sandstone, slate clay or shale, clay ironstone, and fire clay or marl; these are the most usually met with: limestone, clay porphyry, and greenstone, are of more rare occurrence.

The sandstones of the coal formation are composed of siliceous particles of various degrees of fineness, cemented together by a calcareous or argillaceous paste; they frequently contain impressions of large seeds, and stems of trees, but they are seldom more than mere casts, for rarely does any vegetable matter remain. Sometimes, however, trees, or their roots, are found, in which the body is occupied by sandstone, while the bark is converted into coal. These sometimes lie in a horizontal position, and are compressed, as if with great force, into a flattened form, while others are found erect, as if in the position in which they grew.

Coal sandstones are often micaceous, and therefore split easily, and form a cheap, durable, and ornamental building stone. Slate clay, or shale, is usually very abundant; it is a dull, earthy mineral, which easily splits into thin plates. It decomposes rapidly, when exposed to the atmosphere; its colour varies from black, to blueish black, grey, or reddish. The shale at Ape Dale, beyond Newcastle under Line, presents the most beautiful impressions of the barks of canes, and other exotic vegetables, ever seen; some of them are of the most delicate organization that can be imagined, and unlike any thing with which naturalists are acquainted.

Impressions of fishes, of muscles and snails, are not uncommon. The most remarkable examples of these occur in the shale of Mount Bolca, in the Veronese territory, where a great number of fish are enclosed, which seem to have been surprised almost instantaneously, as most of them appear to struggle, and one is in the very act of swallowing another. Among them, naturalists have recognised 27 kinds of fish of the European seas, 39 of the Asiatic, 3 of the African, 18 of South America, 11 kinds of fish of North America, and 7 kinds of fresh water fish of different parts of the world.

In the neighbourhood of the Potteries, in Staffordshire, the shale abounds with remains, of a yellowish colour, resembling the petals of flowers; in Shelton, the fossil is found, which is like a cane in the stem, but has linear leaves, like grass, issuing from all parts of it. The organic remains found in shale, are always in a state of great compression; whether vegetable or animal, they are crushed flat, and always lie in the direction of the thin plates which form the rock, and never across them; which must have been caused by the action of water floating them on in layers.

Clay ironstone is generally found interstratified with shale, or fire clay; it is either in flattened nodules, detached from each other, or in beds, which frequently are only two or three inches in thickness, and rarely exceed six inches. This substance increases in weight in proportion to the quantity of iron it contains. Nearly the whole of our English iron is made from this substance, which sometimes contains 50 per cent. of iron, but rarely more than from 20 to 25 per cent. That which is procured at Ape Dale is of a very fine kind. The nodules of ironstone, found of a flattened shape, and about 3 inches wide, generally contain some vegetable remains, mostly of the fern kind. Near the bottom of the coal basin on which the Staffordshire Potteries are situated, there is a layer of ironstone, full of shells of the muscle kind; a similar layer, 18 inches thick, is found in Derbyshire, extending from Stavely to Tupton Moor.

Fire clay is a substance which has received no particular mineralogical name; its colour is grey, of various shades, but usually light smoke grey. It is very soft, and its fracture earthy. It often contains impressions of reeds, rushes, and other aquatic plants. When decomposed, by exposure to the air, and ground fine, it makes the finest crucibles, and other articles, which are required to endure intense heats, as in glass-houses, and furnaces.

Having described the general circumstances under which coal is found, we shall now proceed to a more particular description of the principal deposits of this important article. The great coal field of South Wales, extending from Pontypool to St. Bride's Bay, belongs to the independent formation, and is situated in a limestone basin, the length of which is about 100 miles; the average breadth in Pembrokeshire is from 3 to 5 miles, and in the other counties from 18 to 20 miles, but is broken into by Swansea and Carmarthen bays. The deepest part of this basin is near Neath; the lowest strata of coal are near 1400 yards lower than the outcrop of some of the superior strata in some of the hilly parts of the district. The upper bed of coal lies about 120 yards deep in the centre, and rises at about a mile distance north and south; and also a few miles east and west of the deepest part of the basin; between the outcrop of this top coal and the limestone, all the lower coals creep out in succession, the outcrop of the bottom coal being of course *next* to the limestone.

There are 12 beds of coal, from 3 to 9 feet thick, making together 70½ feet of coal. Also 11 others, from 18 inches to 3 feet thick, making together 24¾ feet; so that there are 95 feet of workable coal, besides numerous smaller beds, from 6 to 18 inches thick; by taking the average length and breadth of the whole coal field, it may be stated at 1000 square miles, containing 95 feet of coal in 23 strata, which in the common way of working will produce 100,000 tons per acre, or 64 millions of tons per square mile: 64 millions of tons is a quantity which will not soon be exhausted.

The regular course of the coal in this district is frequently deranged by dislocations or faults. These irregularities are not confined to the edges of the strata, but take grand ranges through the interior of the basin, rending the whole to pieces, and throwing the strata up and down, to the extent of 80, 160, or 200 yards at a time.

The coal on the north-eastern side of this deposit is of a coking quality; on the north-western it is stone coal; and on the south side it is principally of a bituminous or binding quality.

In Gloucestershire, the coal is bounded by limestone; these rocks begin at Cromhall, and meet again in Somersetshire; thus giving to the basin an elliptical form. Coal is found every where within this district, but is most abundant in the Forest of Dean, where no fewer than 120 coal pits are worked.

The Wrekin, in Shropshire, is composed of greenstone, sandstone, and a rock having the appearance of a pudding-stone; it rises from the plain near the banks of the Severn, forming a ridge two miles in length. On the east side of this mountain lies the coal district of Colebrook Dale; this is about eight miles long and two broad. The whole of this district is considerably above the level of the plain of Shropshire; and the southern parts of it are not less than 500 feet above the surface of the Severn. It is composed of the usual members; namely, siliceous sandstone, indurated clay, slate clay, and coal, alternating with each other without much regularity. The whole series is most complete at Madely colliery, where a pit has been sunk 264 yards, through all the beds, 86 in number, that constitute this formation. The sandstones, which make part of the first 30 strata, are fine-grained, considerably micaceous, and often contain thin plates, and minute fragments of coal. The 31st and 33d strata are coarse-grained sandstone, entirely penetrated by petroleum; they are both together 15½ feet thick, and furnish the supply that issues from the spring of mineral tar at Coalport. Clay porphyry occurs but once in the series, it forms a bed 9 inches thick, at 75 feet in depth from the surface; its character is the same as that lately found in Hanley, in Staffordshire. The first bed of coal occurs at the depth of 34 yards, and is only 4 inches thick; nine other beds, somewhat thicker, lie between this and the depth of 132 yards. They are termed stinking coal, are very sulphureous, and are only used for burning lime. The first bed of coal that is wrought is 5 feet thick; beneath which is one 10 inches, and another 3 feet thick; besides nine beds, whose aggregate thickness is 16 feet. But of the numerous beds visible in this colliery, some are wanting in the neighbouring ones; for the strata have undergone such violent changes and dislocations. The middle part of the coal field has either been elevated, or the sides have fallen down; as the corresponding strata are from 1 to 200 yards lower on the east and west sides than in the middle.

The coal strata of Derbyshire are traversed, and dislocated by an immense fault, proceeding in a zig-zag direction from south to north. By this means the coals are thrown into such confusion, that it is almost impossible to calculate with any certainty upon the position of them. The strata of which the whole formation consists, are numerous; there are 20 gritstone beds; numerous strata of shale and indurated clay, alternating with several beds of coal of different thickness and value. The whole series lies upon the millstone grit, beneath which no coal is found. Some of the gritstone beds contain a sort of muscle and anomia shells, but they are rare. Others enclose ironstone, containing coaly impressions of vegetables.

Besides the great fault just noticed, as traversing the coal from north to south, there is a very extensive one which runs nearly east and west, proceeding from near Nottingham. The effect of this is very important, as the coal on the north of it is raised to a level with the red marl on the south; that is, the coal, which, in all its natural situations, is below the red marl, is here thrown up to it.

The Whitehaven coal mines on the coast of Cumberland, have their inclination or dip of the beds nearly west, the fall being 1 yard in 10. The strata are frequently interrupted by dykes and fissures, producing dislocations to the depth of 120 feet. In a depth of 230 yards, there are 7 large beds of coal, besides 18 thin beds, not worth working. Two collieries have been established on the coal fields in the vicinity of Whitehaven, one of which extends over an area of 2300 acres, and is carried under the bed of the sea, for the space of 900 yards. One pit is wrought to the extraordinary depth of 298 yards; and is supposed to be the deepest coal pit in Britain.

The coal mines of Whitehaven may be considered as the most extraordinary in the known world. They are excavations which have in their structure a considerable resemblance to the gypsum quarries of Paris, and are of such a magnitude and extent, that in one of them alone, a sum exceeding half a million sterling, was, in the course of a century, expended by the proprietors. Their principal entrance is by an opening at the bottom of a hill, through a long passage hewn in the rock, leading to the lowest vein of coal. The greatest part of this descent is through spacious galleries, which continually intersect other galleries, all the coal being cut away, with the exception of large pillars, which, where the mine runs to a considerable depth, are nine feet in height, and about 36 feet square at the base. Such is the strength there required to support the ponderous roof.

The mines are sunk to the depth of 130 fathoms, and are extended under the sea, to places where there is above them sufficient depth of water for ships of large burden. These are the deepest coal-mines which have ever been wrought; and perhaps the miners have not in any other part of the globe penetrated to so great a depth beneath the surface of the sea; the very deep mines in Hungary, Peru, and elsewhere, being situated in mountainous countries, where the surface of the earth is elevated to a great height above the level of the sea.

In these mines there are three strata of coal, which lie at a considerable distance one above the other, and are made to communicate by pits; but the vein is not always continued in the same regularly inclined plane, the miners frequently meeting with hard rock, by which their further progress is interrupted. At such places there seem to have been breaks in the earth, from the surface downward, one portion appearing to have sunk down, while the adjoining part has preserved its ancient situation. In some of these places, the earth has sunk 20 fathoms, and even more, while in others, the depression has been less than one fathom. These breaks the miners call dykes; and when they reach one of them, their first care is to discover whether the strata in the adjoining part are higher or lower than in the part where they had been working, or, according to their own phrase, whether the coal be cast down or cast up. In the former case they sink a pit; but if it be cast up to any considerable height, they are frequently obliged, with great labour and expense, to carry forward a level or long gallery, through the rock, until they again reach the strata of coal.

The coal district of Northumberland and Durham is of greater magnitude and importance than any in the world. It supplies London and all the eastern and southern coasts of the island with coals. The quantity of coal which it annually yields, is scarcely inferior to what is furnished by all Europe, out of Great Britain.

This great coal-field may be said to be included in a kind of triangle, comprehending about 80 miles of coast. The country rises as it recedes from the sea, until we arrive at the top of Cross Fell, one of the highest mountains in England, being 2901 feet above the level of the sea. The whole tract consists of a series of beds which dip toward the east, so that the lowest of them, which near the sea is at a great depth, rises to the surface at Cross Fell, and then by its dip eastward, is calculated to lie 774 yards below the lowest of the Newcastle beds at that town.

There are 40 beds of coal in this field, but many of them are inconsiderable in point of thickness. The two most important are distinguished by the names of High Main and Low Main. The thickness of the first is six feet, and that of the second six feet and six inches; one is 120 yards above the other, and eight beds are found between them, one of which is four feet and another eight feet thick. These beds yield about 700,000 chaldrons, or 1,500,000 tons, annually, for exportation, giving employment to nearly 1000 vessels.

The mine at Felling was considered, by the workmen, as a model of perfection, in the purity of its air and orderly arrangements; but in May, 1812, an explosion of fire-damp took place in this colliery, in two heavy discharges. A slight trembling, as from an earthquake, was felt half a mile round, and the noise, though dull, was heard 3 or 4 miles: 93 persons perished by this explosion!

The annexed accurate section of the Newcastle coal-mine will be found highly gratifying to every inquirer into the nature of strata of coal countries.

The total annual consumption of pit-coal in England is stated to be 23,669,400 tons. A ton is about a cubic yard, and, taking one yard in thickness as the basis of calculation, it will give 305 yards per square mile of annual supply. And, supposing the coal to extend throughout the whole sub-surface of the country, then the whole quantity would be exhausted in about 10,000 years. But recent observations in some of the Staffordshire mines, have shewn that where some of them have been worked out, the workmen have only to work lower, and they find stratum below stratum, beyond all conjecture where they will stop. Thus, we might furnish all the world for a thousand years with coals without fear of exhaustion.

The most memorable colliery or coal-work that we have ever had in this island, was that wrought at Burrowstounness, under the sea. The veins of coal were found to continue under the bed of the sea in this place, and the colliers had the courage to work the vein near half way over; there being a moat half a mile from the shore, where there was an entry that went down into the coal-pit under the sea. This was made into a kind of round quay or moat, as they call it, built so as to keep out the sea, which flowed there 12 feet. Here the coals were laid, and a ship of that draught of water could lay her side to the moat, and take in the coal. The fresh water which sprung from the bottom and sides of the coal-pit, was always drawn out upon the shore by an engine, moved by water, that drew it 40 fathoms. This coal-pit continued to be wrought many years, to the great profit of the owners, and the wonder of all that saw it; but, at last, an unexpected high tide drowned the whole at once; the labourers had not time to escape, but perished in it.

Coal is never found in the primitive nor transition rocks, but in a third class of rocks very regularly stratified, the most common of which are, 1st, sandstone; 2nd, slate clay; 3rd, indurated fire clay; 4th, argillaceous ironstone; 5th, limestone; 6th, greenstone. In the coal, and in all its accompanying strata, distinct organic remains are found, belonging to the animal and vegetable kingdom.

Coals are among the greatest blessings conferred on civilized countries, and a chief cause of our national prosperity. We have fuel without woods, and better fuel for every purpose of manufactures than any other kind. Great Britain yields seven varieties of coal, as follows:

Cubical Coal is black, shining, compact, and moderately hard; when wrought, it turns out in quadrangular masses, and when broken small, the fragments are cubical. The lamellated structure, or what is termed the reed of the coal, is always parallel to the bed or strata upon which it rests, as is the general case of all coals, with a very few exceptions. Of this coal there are two kinds, the caking coal, and the open burning coal. The caking coal of the best kinds, however small when kindled, undergoes a semi-fusion, and unites into a solid mass. The open burning coal, burns more rapidly than the former, with much flame and heat; the caking coal is very abundant in England, the other is abundant both in England and Scotland. The cubical coals which unite when set on fire, are known by the name of caking or smithy coals; the open burning coals by the name of rough coal, cheery coal, and clod coal.

Slate Coal is black, compact, and much harder than the first species; dull in the colour; in working turns out in large quadrangular masses, which can with ease be split into very thin pieces, similar to slates; hence the name. This coal is open burning, and produces much flame and smoke; it contains a greater proportion of white ashes than the cubical coals. Some of the inferior kinds of this coal burn with difficulty, and produce a great quantity of white ashes. This coal is commonly known by the name of splint coal.

Glance Coal is black, with bright metallic lustre, and brittle; it has the external characters of the preceding species of coals, but the chemical properties of charcoal, hence termed by some mineralogists *native* *mineral carbon.* It burns with considerable heat, with a blue lambent flame, produces no smoke, and leaves a small proportion of ashes; it appears to have a portion of sulphur in direct combination, so that in burning it gives out a most suffocating effluvia; it produces no soot, but, on the contrary, whitens the places where the fumes are condensed. This kind of coal abounds in Ireland, and is known by the name of Kilkenny coal; it is the blind coal of Scotland, and the malting, or stone coal of Wales.

Cannel Coal is black, with little lustre; in working it turns out four-sided columnar, breaks with a conchoidal fracture, in any direction, like pitch, ignites very easily, and burns with a very bright flame like a candle, from which it derives its name. It is found very abundant in the coal field at Wigan, in Lancashire, where there is an entire stratum of it about four feet thick, without a mixture of any other coal. It produces very little dust in working, and does not soil the fingers as the other coals do; varieties of this coal are found in Scotland, forming frequently part of the thickness of the common coals. What is termed pitch coal by some mineralogists, is only a variety of this species. The cannel coal, when first kindled, decrepitates very much, throws the burning splinters to a distance, and is on this account dangerous; it is said that this fault is corrected by immersing the coals for some time in water, previous to their being used for fuel. In Scotland, this coal is termed parrot coal, or bottle coal.

Sulphureous Coal is of a dull black colour, mixed with a great proportion of pyrites. Though pyrites is found in distinct pieces in coal, this occurrence does not constitute it a sulphureous coal, because the pyrites can easily be picked out; but sulphureous coal, properly so called, has the pyrites so interwoven with its texture in small veins, or so intimately combined with the principles of the coal, that the sulphureous parts cannot be separated. It is very unsafe to work such coals, because if any quantity of the small coals produced in working is left below ground, a decomposition ensues, heat is generated, and the mine is set on fire, of which there have been many instances.

Culm Coal is of a dull black colour, small and dusty; by some mineralogists it is reckoned a distinct kind of coal, at least such is said to be the case in Sweden. What is termed culm, in Great Britain, is the refuse or small dusty coal produced in working the common coals.

Bovey Coal, or bituminous wood, is found in alluvial land, though some mineralogists affirm that it is found in the rock stratification. It is composed of trees, reeds, and rushes imbedded in the alluvial earth, the form of the trees, the ligneous and fibrous texture, being, in most cases, distinct; their texture is impregnated with petroleum, and combinations of the sulphuric acid. When first dug up, the fibres are flexile; in burning, it produces little heat, and a very unpleasant smell, and is only used where other kinds of fuel are scarce and high in price. In England it is found in greatest abundance at Bovey, near Exeter, from which it derives its name; it also abounds in many parts of the continent, particularly in Germany.

The *cubical* and *slate coals* are chiefly used as fuel in private houses, and in all manufactories where a strong heat is required; the caking coals are most suitable for smith's fires; when any of these coals are made into coke, they produce an intense heat in the blast furnace for the making of iron, being used with success in place of charcoal; the slate coals of the best kinds suit this purpose excellently, as from their strong texture they bear a heavy load of ironstone and a strong blast.

The *coals of South Wales*, employed in the making of iron, contain less volatile matter than either the English or Scotch coals; so that in producing a ton of pig iron, only about half the quantity of coals is requisite, as a given quantity contains a great proportion of carbon. Lord Dundonald invented a process by which the volatile parts of the coal were condensed, producing volatile alkali, oil, and tar; the coals thus distilled were converted into excellent coke, and applied for the purpose of making iron.

For the production of intense heat and flame in a furnace, the *slate coals* are most suitable, as, by keeping open, they admit a constant supply of air, which preserves a vehement combustion; on this account, they are in great request by the Scotch and Irish distillers. *Glance coal* is used in Ireland as common fuel, and sells at a high price. It is much used for drying grain and malt; to these it imparts a fair colour; it is for this latter purpose that the Welsh and Scotch coals of this kind are chiefly used. It is also used for the burning of lime, for which it is very suitable. *Cannel coal* is chiefly used for common fuel: that which is found in Lancashire admits of being turned on the lathe, and is made into a variety of utensils and ornaments, being susceptible of a very high polish, nearly equal to that of jet; and of the various coals it is said to be the most suitable for producing the coal gas used for lighting up large manufactories. *Sulphureous coal* is but very little used, being so dangerous to work; it is only suitable for the burning of lime, the making of salt, or for producing sulphate of iron. *Culm* is used for burning of lime, making of salt, and for steam engines; it sells at a very low price. There is but a small consumption for this coal in comparison of what is produced annually in the mines. *Bovey coal* is only used as common fuel by the poorer classes of the community, where better fuel cannot be had.

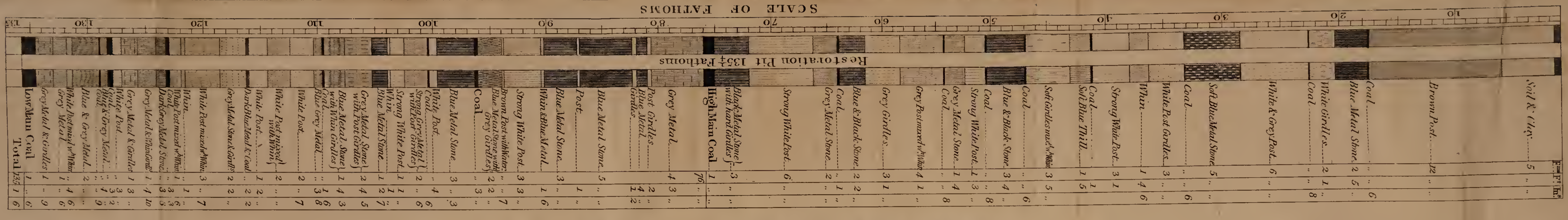
When we attend to the inflammable substances found in the earth, or in the mineral kingdom, we may perceive that very few, and most probably none of them, can be truly said to belong to it, but have been elaborated in the bodies of animals or vegetables. From the turf that is pared from the surface of the earth, and owes its inflammability to the roots of vegetables which are mixed with it, we may descend to the peat, or black earth, of the moors, in many specimens of which vegetable remains are still perceptible; though in most they appear to be deprived of every appearance of their organic texture, their oily and inflammable nature only remaining; and thence the transition to pit-coal is easy. For if we reflect on the vast revolutions which the earth has certainly undergone through a long course of ages, by means of which its surface has been broken, displaced, and inverted, by the actions of floods, earthquakes, and the great convulsions of nature, caused by volcanic eruptions, it will be no improbable inference, that the thin, though extensive strata of pit-coal, as well as the exudations of naphtha, petroleum, and their modifications, have all arisen from the burying of extensive woody tracts of the surface, such as are common in all uncultivated countries. And this probably will be reduced to a certainty, when we studiously advert to the natural history of pit-coal, as it is met with in all the various states of transformation. Whole trees are converted into pit-coal, in such quantities together as to exhibit entire forests; in which the roots, trunks, branches, bark, and even species, are discernible.

The operations of miners are often interrupted by explosions of gas called fire damp, which is evolved in great abundance in coal pits; and the most terrific and fatal explosions take place. It is the *carburetted hydrogen gas* of chemists, and 100 parts is composed of 72 of carbon and 28 of hydrogen; or of seven atoms of hydrogen, and three of carbon. Fire-damp is formed by the action of coal upon water. The water is decomposed, two atoms at once; all the oxygen combines with carbon, and forms carbonic acid; while all the hydrogen unites likewise with carbon, and forms carburetted hydrogen, or fire-damp. The coal appears to part with a portion of its carburetted hydrogen, when newly exposed to the atmosphere; because it is more inflammable when fresh from the pit than after long exposure to the air. Another source of the gas may be from the water, which is constantly decomposing, by the action of the pyritous shales, which process is going on in all the old workings, and must be productive of great quantities of hydrogen. The abundance of it is surprising, and it frequently takes fire in a shaft, long before the coal itself is reached by the sinkers; and when the pitmen occasionally open, with their picks, crevices in the coal or shale, as much as 700 hogsheads of fire-damp have escaped in a minute. These blowers, as they are termed, continue in a state of activity for many months together, and seem to derive their energy from communicating with immense subterraneous reservoirs of air. The after-damp or stythe, which follows these blasts, results from the combustion of the carburetted hydrogen, in atmospheric air; and more lives are destroyed by this than by the violence of the fire-damp. To guard against these accidents every precaution is taken that prudence can devise, in conducting and ventilating the mines; yet, in spite of every care, and even of Davy's safety lamp, explosions frequently take place, and in some instances, a hundred men at once have been destroyed.

Coal pits and slate quarries exhibit innumerable marks of impressions of leaves, and other indications of their vegetable origin; and the analysis of this combustible substance tends still further to confirm this conclusion. On the other hand, if we attend to such inferences as chemical theory might point out from the facts around us, we shall see how small the probability is, that the mineral kingdom should, after a limited time, contain inflammable bodies, if they were not occasionally thrown into it, in consequence of the operations carried on within organized substances. For all inflammable substances tending to decompose the oxygen of the atmosphere, would, in process of time, revert to the class of uninflammable bodies, if the operations of organized bodies, particularly of the vegetable kind, did not tend to disengage the oxygen again, and render bodies combustible, which were not so when they became parts of their substances.

Ireland also possesses several deposits of coal. The Leinster district is deservedly famous; and from Mr. Griffiths's account of it, we have copied a fine engraving of part of the variegated strata of which it consists. The plate explains itself by means of the key on the left and the shadings of the strata, and if duly examined explains more relative to the formation of the earth's surface than a hundred pages of description could effect. The famous Kilkenny coal is found in this district, in a bed three feet thick, and is found to contain 96 per cent. of pure carbon, and only 4 per cent. of ashes. There are altogether six beds of various, and the worst is co-

THE NEWCASTLE COAL-PIT STRATA.



THE STRATA OF THE LEINSTER COAL DISTRICT.

vered by a bed of black slate clay, interstratified with beds of clay ironstone, usually one inch in thickness; these alternations continue to the surface, and form the uppermost strata of the coal district.

The quantity of coal annually raised in the principal division of the Leinster coal district may be, on an average, about 70,000 tons of hard coal, and about 100,000 of soft coal or culm. The whole of the hard coal is raised from the Castlecomer and Newtown collieries, but in addition to them, culm is raised at the Firoda, Tollerton, Wolf Hill, and Clogrennan collieries, which increases the quantity of culm raised.

The annual produce of the French coal mines is stated at nearly 5,000,000 of tons. The department of Jemappe contains the richest coal mines in France; and there are no less than 300 pits wrought in that field, in which no fewer than 25,000 persons are constantly employed at work, under ground. The coal of Ansin, near Valenciennes, is the most surprising, as the beds are folded up and down, so that the same coal rises near the surface, and dips suddenly again.

No coal has yet been found in Spain, nor in Italy, except a small quantity in the north. In other parts of the European continent, as in Silesia, Germany, and Bohemia, there are mines, some of which yield it in abundance. The greater part of the north of Europe, except some small patches in Russia, seem destitute of coal. There is a small quantity in the vicinity of Moscow, but not sufficient for the supply of that great city.

The extensive countries of Asia, China excepted, scarcely afford any indication of coal. On the banks of the Pekiong, a river which passes by Canton, in its way to the sea, some collieries were observed by the suite of Lord Macartney. Several of the mines are described as very extensive, but the coal is bad Even the coal dust, which is usually neglected in this country, is not lost by that industrious and economical people. It is mixed with soft earth, reduced to the form of bricks, and conveyed to those parts of the empire that are destitute of fuel.

No coal has yet been found in the immense regions of Africa. The United States possess some good coal formations, particularly in Virginia, where there is a bed of coal, 42 feet thick, which lies so near the surface, that the earth which covers it is removed, and the coal dug out, like stones, from an open quarry.

The first mention of British coal in history, is by Solinus, who evidently indicates the use of coal, when, mentioning the medicinal waters at Bath, he says, "They are dedicated to Minerva, in whose temple the perpetual fire does not leave embers, but is changed into rocky lumps." This pretended miracle was the natural progress of a coal fire. But though coal appears to have been known so early in this island, the abundance of wood and turf prevented the natives from digging into the bowels of the earth for what the surface afforded so amply. Even when wood became scarce, at the distance of several centuries after the discovery of coal, the manner of working it was extremely rude, the progress and extent of the use of it slow, and limited. In the *Leges Burgorum*, which were enacted about the year 1140, a particular privilege is granted to those who bring fuel into boroughs. Wood, turf, and peats, are particularly mentioned, but there is no mention of coal.

Henry III., in the year 1234, renewed a charter which his father had granted the borough of Newcastle, and granted, upon their supplication, the liberty to dig coals, upon the payment of £100 per year; this is the first time that fuel is noticed in history. Eneas Sylvius, who afterwards became Pope, under the name of Pius II., visited this island about the middle of the 15th century. He relates that he saw the poor people who begged in rags, receive for alms, pieces of black stone, with which they went away contented. "This species of stone," says he, "whether with sulphur, or whatever inflammable substance it may be impregnated, they burn instead of wood, of which their country is destitute."

In the reign of King John, the coal trade made rapid progress, but its use was shortly after prohibited, in London, under the apprehension that its smoke was poisonous. The quantity at present consumed in the metropolis, may be conceived, from the amount of the duty upon coals coming into the port of London. In 1677, King Charles II. granted to his natural son, the Duke of Richmond, for his maintenance, a duty of one shilling per chaldron, on coals; the right to this impost continued in the same family until the year 1800, when government purchased it, for the payment of £19,000 per annum, to the Duke and his heirs. This duty now amounts to above £25,000 a year.

There are few coals but what present more or less of a woody texture. This appearance may be traced from the bitumenized wood, which still bears, though approaching in its nature to coal, the trunk, the branches, and even, in some instances, the very leaves of trees, through all the varieties of coal, into the most compact, slaty kind, of the oldest formation*. Nor is it less remarkable that the shale which uniformly co-

* In confirmation of these observations it may be remarked, that in Ireland, a standing forest was lately discovered, at the depth of 100 feet beneath the present surface of the soil; that in Lancashire over-

vers the independent coal formation, *always* encloses vegetable remains, and the greater part of those geologists who have given their attention to the probable origin of coal, consider it as derived from vegetation.

LECTURE XXVI.

ON CRYSTALLIZATION AND PRECIOUS STONES.

Th' unfruitful rock itself, impregn'd by thee,
In dark retirement forms the lucid stone.
The lively DIAMOND drinks thy purest rays,
Collected light, compact.—
At thee the RUBY lights its deepening glow,
And with a waving radiance inward flames.
From thee the SAPPHIRE, solid ether, takes
Its hue cerulean; and of evening tinct,
The purple-streaming AMETHYST is thine.
With thy own smile the yellow TOPAZ burns.
Nor deeper verdure dyes the robe of Spring,
When first she gives it to the southern gale,
Than the green EMERALD shows. But all combin'd,
Thick through the whitening OPAL play thy beams;
Or, flying several from its surface, form
A trembling variance of revolving hues,
As the site varies in the gazer's hand.

ALMOST all solids, when examined with a microscope, are found to present regular forms. Some are more palpable than others, and the more perfect operations of nature may be imitated by art. The forms thus presented by solids, are called CRYSTALLINE or CRYSTALS. When classed they are not numerous, and are worthy of being remembered. They are:

turned forests have been found, but a few feet beneath the soil; that in digging in the Isle of Dogs, and to the west of Hastings, trees and shrubs were found, standing erect, at a depth of 30 feet; and that, at the present day, the navigation along the shores of Lake Superior, is rendered inconvenient by bodies of trees, projecting horizontally from the cliffs, 25 or 30 feet below the top of the cliff, serving beyond all question as materials for coal beds, in remote future generations. The succession of coal beds, one over the other, with strata between, seems to prove that the causes must have been repeated as many times as there are such beds; that is to say, if, according to the theory of Sir R. Phillips, there are 10 such beds, they would have been 200,000 years in forming. Hence, our opinions are exalted, in regard to the sublime passage of Moses, in which he says, "*In the beginning* God created the heavens and the earth," which remote *beginning* seems to be carried back, by these natural phenomena, through many hundred thousand years; and although this is contrary to the common interpretation of the sublime and sacred passage in question, yet it is, at the same time, perfectly reconcileable with it,

1. The PARALLELOPIPEDON, which includes cubes, rhomboids, and all figures of six paralleled sides:

2. The TETRAHEDRON, with four triangular sides:

3. The OCTAHEDRON, with eight triangular sides;

4. Six-sided or hexahedral Prism:

5. The DODECAHEDRON, bounded by twelve *rhomboidal* sides:

6. The DODECAHEDRON, with twelve *triangular* sides: *(See the Engravings and Descriptions.)*

To some of these forms most solids may be reduced. Whether they afford evidence that primæval or primary atoms are of one form, is still a question among philosophers. Some have supposed that primary atoms consist therefore of simple *pyramids*, simple *cubes*, and simple PRISMS; because, by the composition of these three forms, the six above named may be compounded. But others contend that primary atoms, if infinitely small, may nevertheless be only spherical, because the three forms may be *compounded* out of spherical atoms, forming a pyramid, a cube, &c. just as we see cannon balls arranged. Indeed, Mr. Lowry has beautifully exemplified this principle of composition by mechanical arrangements, and has shewn that different layers of atoms, of one form, added or subtracted, are capable of producing all the forms in which matter reaches our senses.

Nevertheless, says Sir R. Phillips, the various conflicts of bodies, and the resulting phenomena, seem to render it probable, that the varied results may arise from the three forms indicated by the Abbé Haüy; for, if we suppose primary atoms to be of one form, other elements must then be introduced, the supposition of which is gratuitous, and the forms of cube and pyramid, with the universal adjunct of motion, seem competent to the production of all phenomena; we may thus reason with safety, because by subdivision we must arrive at ultimate particles of matter; yet the same writer justly observes, that these inquiries baffle human comprehension; for an ultimate atom may only bear the same relative proportion to a grain of sand, which a grain of sand bears to the whole earth. The atoms, therefore, about which our inquiries are generally directed, must be regarded as compounded, and capable of many subdivisions, though doubtless their phenomena must be, and are, varied by the proximate action of others immeasurably smaller.

Of course atoms of certain regular forms, acted upon by others in motion, and with greater force on their outsides than their insides, must be driven together, and if patients of a regular action, must unite on their sides, fill up interstices, and form, in due time, regular forms or crystals. Their union would be the result of the same force of atomic motion, or gaseous elasticity, which drives bungs together, or to the sides, when floating on water, in a vessel, or which made the plummet go to the mountain at Schehallien. Time alone is necessary to the result, and nature does nothing in haste, or, rather, what is done, has been done in the requisite time.

The very principles of all cohesion are, therefore, the principles of crystallization, the resulting external forms (*i. e.* the special direction of the atoms or polarization) being consequences of re-actions of the medium or gas, in which the operation takes place; and the actual forms resulting from the pressure of that medium upon atoms of particular forms, for in the vacuum of an air pump, *crystallizations* do not take place in the manner they do in the air.

The usual means of producing experiments in crystallization, is dissolving some salt in water, gradually evaporating the water, and then the atoms of the salt are packed by the air, in accordance with the forms of its original crystals. If this be done, in connexion with a solar microscope, the operation as magnified, is as delightful as wonderful. At other times, great atomic motion or heat is applied to metals, the atoms of which are thus separated, and acquire the relative motions of fluidity; but on the atomic motion, or heat, being allowed to dissipate itself to surrounding bodies, the metallic atoms again coalesce in their fixed state, and, under peculiar management, form beautiful crystals. So also with resinous substances dissolved in alcohol. And in truth, says Sir R. Phillips, as all fixation or solidification of atoms, in the processes of nature, are made by the intervention of solution, so almost all the matter we see is in crystallized forms, and dissolving and crystallizing are the great and universal operations of progressive and changeable nature. They are, at the same time, mere mechanical operations, slowly performed, and have no connexion with any assumed or arbitrary principles, like attraction or repulsion.

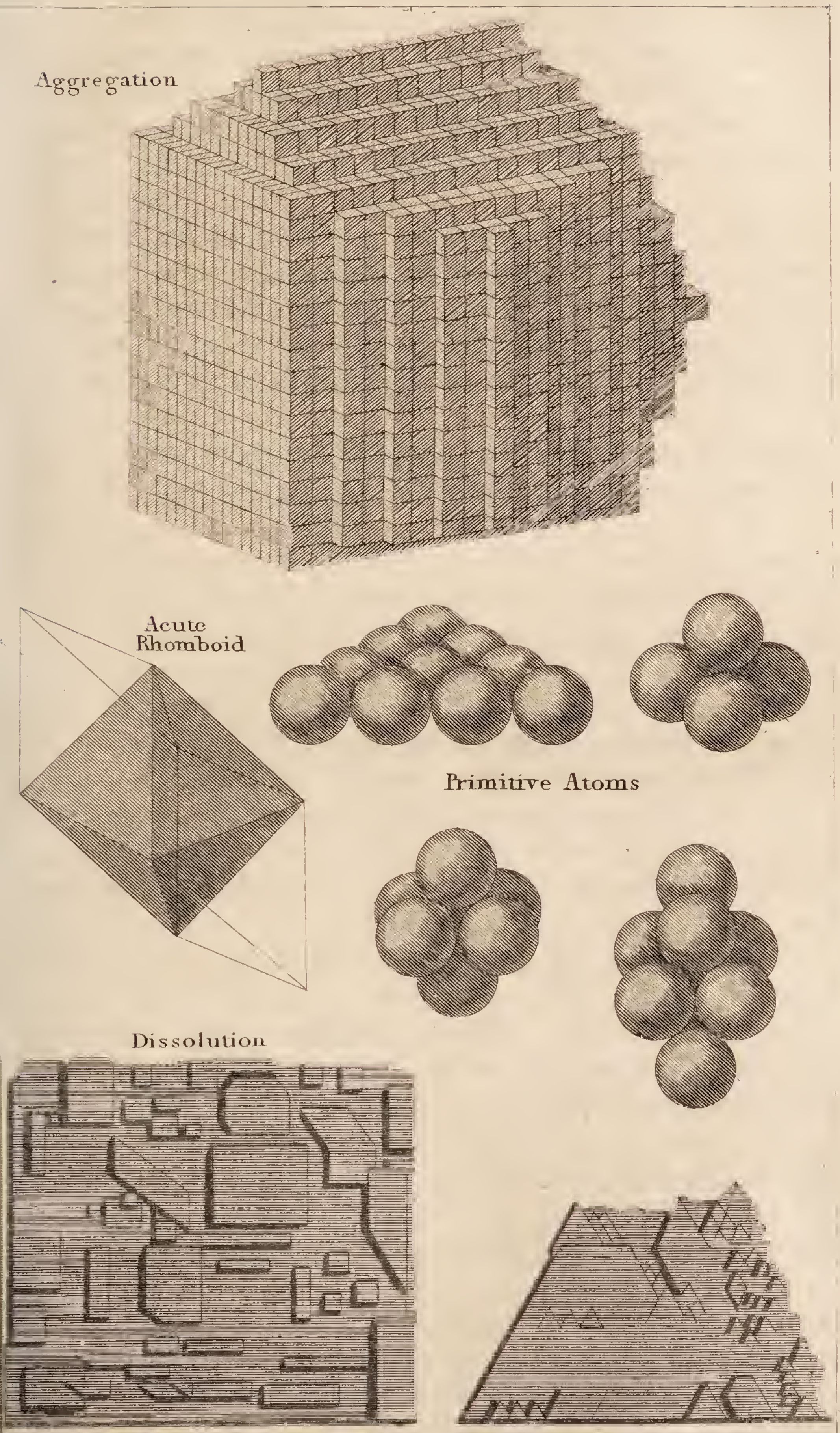
The solid of the primitive form, or nucleus of a crystal, obtained by mechanical division, may be subdivided in a direction parallel to its different faces. All the sections thus produced, being similar, the resulting solids are exactly similar in shape to the nucleus, and different only in size, decreasing as the division is continued. To this division there must be a limit, called the *integrant atom*. If the division of the nucleus were possible in other directions than parallel to the faces, the integrant atom may differ in figure from the nucleus. But the forms of integrant atoms hitherto discovered, are only three:—the *tetrahedron*, the simplest of pyramids; the *triangular prism*, the simplest of prisms; and the *parallelopipedon*, the simplest of solids; the combinations and varieties of which produce six generic forms of crystallized bodies. Yet the combination of this small number of forms is fully sufficient for all purposes of mechanical cohesion, when is superadded the infinite diversity of size, proportion, and weight, to which the particles of different bodies are liable, and yet have the same figure.

The first form is the PARALLELOPIPEDON, including the Cube, Rhomboid, and all the solids terminated by *six* faces, parallel, two and two. In this class are the crystals of amphigene, analime, boracite, native copper, red oxide of copper, arsenical cobalt, fluor spar, native gold, iron pyrites, arseniate of iron, sulphuret of lead, molybdate of lead, mellite, and muriate of silver, as *Cubes*.

Rhomboids, with the angles of their planes more or less acute and obtuse, include crystals of chabasite, corundum, phosphate of copper, oxide of iron, chromate of lead, carbonate of lime, antimonial sulphuret of silver, sulphate of lime, and quartz.

Rectangular Prisms are andalusite, apophyllite, sulphuret of antimony, chrysolite, cymophane, epidote, harmotome, idocrase, muriate of lead, macle, white ox-

CRYSTALLIZATION. *Plate I*



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ide of manganese, mesotype, meionite, muriate of mercury, micarelle, scapolite, stilbite, oxide of tin, oxide of uranium, wolfram, sulphate of zinc, and zircon.

Right Rhomboidal Prisms are gadalonite, yenite, mica, topaz, tremolite, prehnite, arsenical iron, phosphate of iron, and sulphates of barytes, lime, and strontian.

Oblique Rhomboidal Prisms are axinite, sulphate of copper, blue carbonate of copper, corundum, euclase, felspar, hornblende, oxide of iron, carbonate of lime, scapolite, sphene, silica, calcareous titanium. *(See Mackenzie's Experiments, or Mitchell's Chemical Dictionary.)*

2. The TETRAHEDRON includes the crystals of blende, and sulphurets of zinc, grey copper, and pyritous copper.

3. The OCTAHEDRON, in three several varieties, includes crystals of gold, silver, copper, bismuth, and amalgam; oxides of iron, tin, and titanium; red oxide of copper, anastase, ceylonite, diamond, spinelle, mellite, sulphur, arseniate and muriate of copper, chromate and super-sulphuret of iron, iron pyrites, fluate and tungstate of lime, sulphate, molybdate and carbonate of lead, and sulphurets of silver, lead, and zinc.

4. The HEXAHEDRAL PRISM includes crystals of actynolite, arragonite, corundum, cyanite, dichroite, diopase, emerald, epidote, grenatite, hornblende, mica, nepheline, pyroxene, quartz, chorlite, tourmaline, carbonate and sulphate of barytes, arseniate of copper, arseniate and phosphate of lead, carbonate, phosphate and sulphate of lime, red sulphuret of mercury, sulphuret of molybdenum, antimonial sulphuret of silver, and carbonate and sulphate of strontian.

5. The DODECAHEDRON includes crystals of native amalgam, amphigene, ceylonite, red oxide of copper, grey copper, garnet, native gold, fluate of lime, mellite, and sodalite.

6. The DODECAHEDRON, with isosceles triangular faces, includes the crystals of corundum and quartz.

Every crystal may be divided by proper instruments; and when split in certain directions, presents plane and smooth surfaces; in other directions, the fracture is rugged the mere effect of violence; not guided by the natural joining of the crystal. This fact had been long known to jewellers and lapidaries; and an accidental observation of it, by Haüy, furnished him with the key to the whole theory of Crystallization. Mr. Daniell also has decomposed crystals by degrees; and then, on examining their abraded parts, has found that atom after atom was removed, like cubic stones from a mass of masonry.

Among pure crystals, several precious stones present the most interesting objects of investigation and inquiry, and we shall therefore proceed to detail some interesting particulars relative to them in succession*.

The *Diamond*, a model of crystal structure, the most beautiful, and hardest of all such productions, is remarkable, also, for its regular form (the primitive being *octahedron)*, its perfect transparency, and the play and vivacity of its reflections. It is mostly colourless, or of a pale grey, and sometimes brown, green, yellow, rose-red, and blue; commonly spheroidal, with 48 curvelinear triangular faces, six raised on each face of the primitive octahedron. The bulk varies from the smallest grain to that of half a hen's egg. It is singly refractive, and when rubbed, acquires positive electricity, whether rough or polished, which is not the case with any other gem. Its beauty, unrivalled by any substance, natural or artificial, first brought it into esteem, and still supports it. Without any essential colour, it imbibes the pure solar ray, and then reflects it, either too white and vivid to bear viewing more than an instant, or decomposes it into the prismatic colours.

When exposed to a current of air, and heated to the temperature of melting copper, it is found to be gradually, but completely combustible; hence it seems a combination of carbon and hydrogen. When placed in the focus of a powerful lens in contact with oxygen gas, it first becomes clear red, and then appears larger, from the surrounding faint white light on entering into

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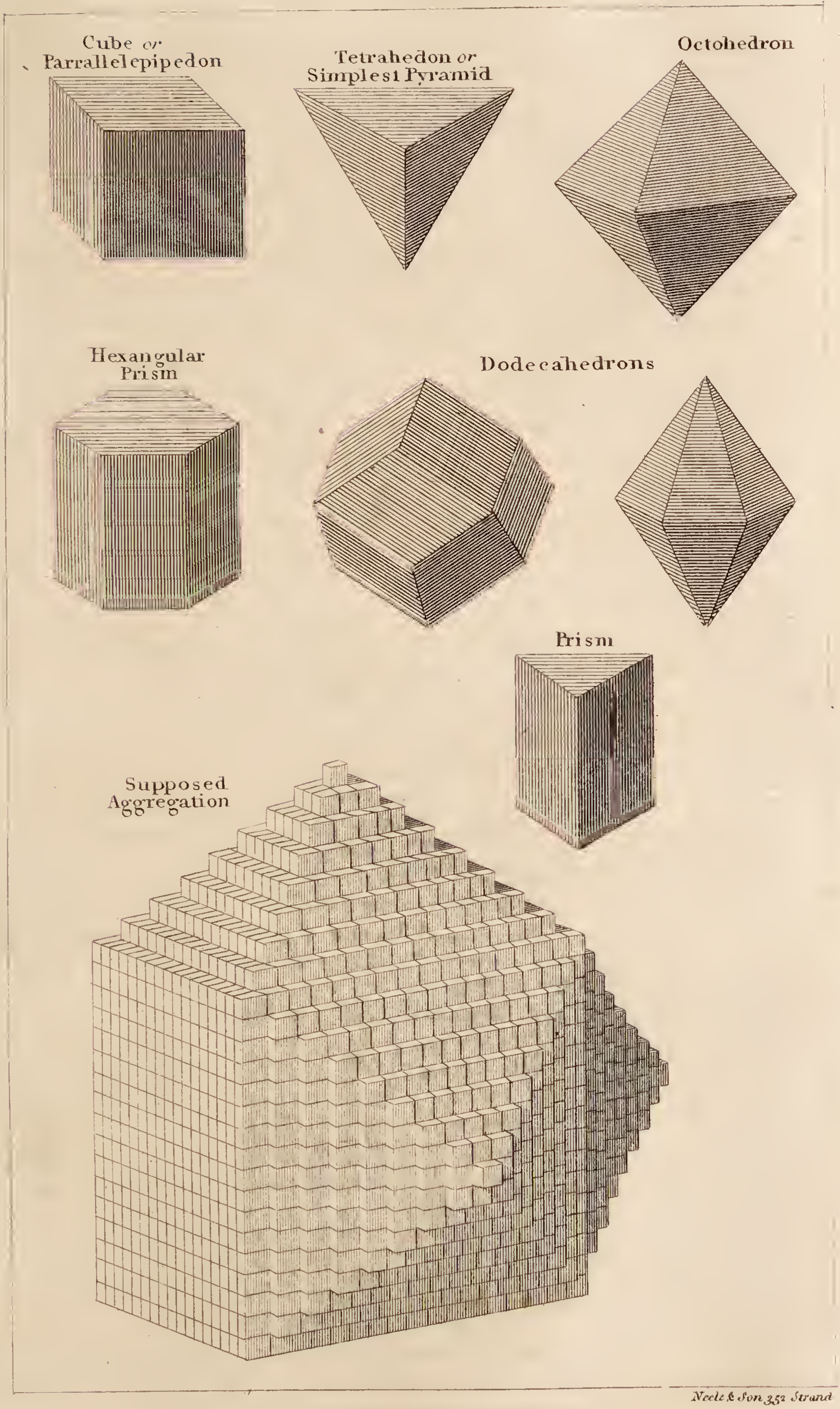
* What is commonly called *crystal*, or rock crystal, is a kind of flint, and is probably the first substance ever noticed as occurring in a regular form: the ancients believed it to be water, permanently congealed by extreme cold, from its transparency; and called it *Krūstallos*, signifying *ice*; but, in time, the word was used without attention being paid to its original meaning, and was applied to all the regular figures observed in minerals.

CRYSTALLIZATION. *Plate II*



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combustion. On slight remission of heat, black minute spots of a leaden metallic lustre appear; the diamond then gradually diminishes, and at length is entirely consumed.—Yet, though in actual ignition, and surrounded with oxygen gas, it instantly ceases burning on withdrawing the focus of the lens. Sir G. Mackenzie placed a diamond on a thin piece of baked clay, and then put it in a muffle previously heated red; it soon became equally red, and in a few seconds more became visible by a bright glow; and, on being removed, was found to have acquired a slight milky appearance; its lustre was impaired, but no black spots appeared on its surface.

Man attaches more value to it, as it is seldom found of a certain size, with all the requisite qualities considered indispensable. Of such, only few are known.

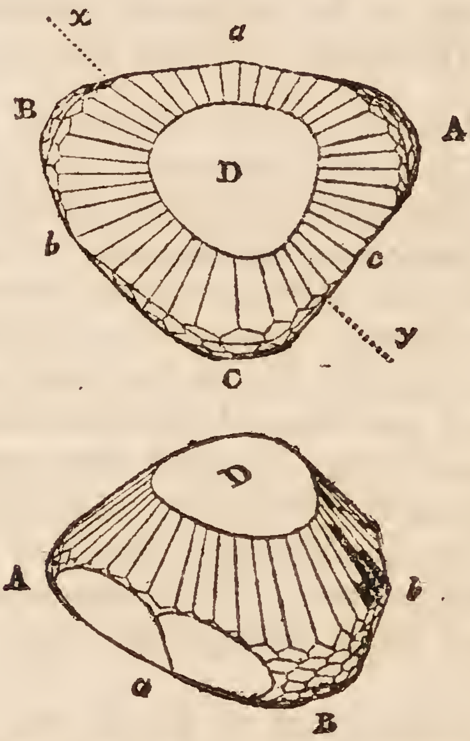
The famous diamond in the sceptre of the emperor of Russia, weighed 779 carats, and was worth by scale 4,854,728 pounds sterling, although it cost but 135,417 guineas. This diamond was originally one of the eyes of a Malabar idol, called *Scheringham;* and a French grenadier, who had deserted from the Indian service, contrived to become one of the priests of that idol, and by that means stole it.

The diamond of the Great Mogul, in form and size resembled half a hen's egg, weighed 298 carats, was cut in rose, and was valued at £700,000. Another diamond, belonging to the king of Portugal, weighed 215 carats, and was worth 369,800 guineas. The diamond of the emperor of Germany weighed 139½ carats, and was worth 109,520 guineas.

That of Nadir Shah, sultan of Persia, was without flaw or fault, in size and shape much like a dove's egg flattened; it weighed 193 carats, and was estimated at £5,000,000. The empress Catherine gave £90,000 sterling, in ready money, also £4,000 per annum, and a patent of nobility, for it.

The Pitt or Regent diamond, worth by scale 208,333 guineas, was found in Malacca, and then was sold, by a Greek merchant, for £80,000 to Mr. Pitt, governor of Bencoolen, who re-sold it for £130,000 to the Regent-duke of Orleans, by whom it was placed among the crown jewels of France. It weighed 136 carats; and, on account of its excessive brilliancy, and being absolutely faultless, it was valued at 12,000,000 livres. Another diamond, belonging to the French crown, called the Sancy, was of a rich sky-blue brilliant, 67 carats in weight, and valued at 3,000,000 livres. The great one of the king of Portugal, was found in the mines of Brazil. It was of a larger size; but a piece was broken off, by the ignorant countryman who, finding this great gem, tried its hardness by the stroke of a large hammer. Taking the multiplicand of the square of its whole weight, 1680 carats (above 11 ounces), at £80 a carat, it is valued at the enormous sum of £224,000,000 sterling.

The great diamond brought from India, for which the Company asked £30,000, was by far the largest diamond in Europe, except the Pitt, and perhaps the Sancy, belonging to France. If its value had been calculated according to its weight, 89¾ carats, it would amount, at £80 a carat, to £637,000.



The upper figure is a geometrical view of the diamond from its upper face; the lower figure is a perspective view, taken in the direction of the dotted line x, y, of the upper figure. The letters A, B, C, set against the angles of the figure, and a, b, c, against the intermediate sides respectively, refer the same parts of the two figures to each other. D, both in the geometrical and the perspective drawing, marks the upper or flat face; and the inclined position of the latter, in the perspective view, indicates the direction of the plane. The engraving is the exact size of the stone.

Zirconium.

The metallic base of the following genus of precious stones, is a white insipid substance, insoluble in pure alkalies, but soluble in alkaline carbonates. The value of the stones from which it is obtained, is, probably, the cause of the present limited state of knowledge concerning the combinations of the substance.

Zircon, and *Hyacinth,* found in France and Norway, but often in Ceylon, with the variety called *Cinnamon Stone,* alone compose the *Zirconian* genus, and have, in their physical characters, great conformity with the diamond; being likewise regular octahedral crystals; the surface smooth and very bright, and lustre approaching nearer the diamond than any others. The zircon is usually grey, but it also occurs green, blue, red, yellow, and brown; the last is yellowish brown; the hyacinth is of red orange passing into a poppy colour, reddish brown, and orange yellow, and when bright and free from flaws is a very superb ring stone.

According to some lapidaries, the zircon comes nearest to the sapphire in hardness; and as they have, when cut and polished, a great resemblance to the diamond, they are called by some *soft diamonds.* The hyacinth, though less striking than any other red gem, is not without its beauty in the finest specimens. It is found from the size of a pin's head to the third of an inch in diameter.

The hyacinth, as well as all other gems, is divided into oriental and occidental; the former being very hard and brilliant, so that they are frequently ranked among the topazes; but when soft, they are supposed to belong to the garnet kind, as mentioned under that article. The hyacinths, however, may generally be distinguished from the garnets by losing their colour in the fire, becoming white, and not melting. There is a kind of a yellow-brown hyacinth, resembling the colour of honey, which is distinguished from the rest by the remarkable property of not being electrical, and being likewise inferior in hardness.

The hyacinth la bella is found both in the East and West Indies. The oriental is the harder, but the American is often equal to it in colour. The rubacelle is found only in the East Indies, and is generally brought over among the rubies; but it is of little value: the other varieties are found in Silesia and Bohemia.

The EMERALD is distinguished from all other stones by its pure unmixed green colour; from its most beautiful pure and full body of colour, down to the palest tinge. The dazzling crimson of the ruby, the golden yellow of the topaz, and the sapphire's sky blue, though rich and exquisite, soon fatigue the eye, which wandering to each is both gratified and irritated. How pleasantly then does it turn to and dwell on the refreshing green of the emerald, which fixes without satiating the attention; emulating the full verdure of spring, the untarnished vigour of vegetation, with all the gratifying associated conceptions. According to Cronstedt, the emerald is the softest of all the precious stones, though other naturalists place it the next after the diamond in this respect. It is perhaps the most beautiful of all the gems, and, according to Wallerius, when heated in the fire, changes its colour to a deep blue, and becomes phosphorescent; but recovers its green colour when cold. Necklaces of emerald have been disinterred from Herculaneum; and in the Museum of Natural History at Paris, is one, known to have adorned the tiara of Pope Julius II. who died about 1492, therefore probably from Ethiopia. M. de Drée has an emerald ring stone with an antique bust of Drusus, son of the Emperor Tiberius. They are now found in Santa Fé, and in the valley of Tunca, the largest known specimens being near six inches long and two thick, but it is rare to find such of a good colour and free from impurities.

The native Peruvians highly esteemed and employed them to decorate their idols of massive gold; and the modern Peruvian papists employ the inferior water-worn varieties, to adorn the pedestals of their crucifixes, and to stud the other articles used in their religious ceremonies. They are often in clusters of artificial flowers on gold stems. They merit the best workmanship; and in pear-shaped ear drops, have a beautiful effect in a diamond oval; or in necklaces and tiaras; but the choicest are set in rings.

The AQUAMARINE or BERYL, is mostly pale sea green, passing into greenish blue, and light sky blue, and into greenish yellow and wine yellow. Their size varies from mere threads to prisms several inches long and three or four thick; but the thick are never sufficiently transparent and perfect for jewellery. The best are procured in Brazil, Siberia, and Ceylon; and inferior in North America, France and Scotland.

THE ARGILLACEOUS STONES,

forming the fourth genus, include many species, which may be classed in five groups, named *Gems, Gemmoids, Schorls, Schists, and Clays.*

GEMS are precious stones, having properties analogous to those of the two preceding genera, with even more perfection in some, as the sapphire, ruby, topaz, &c. but differing from them in alumina being their principal base. They were first distinguished by their colour; the red being called *Rubies*, the blue *Sapphires*, the yellow *Topazes*, and the purple *Amethysts*.

The RUBY most rare, is pure carmine or blood red of much intensity, forming, when well polished, a blaze of the most exquisite and unrivalled teint. It is, however, often more or less pale, and mixed with blue in various proportions; and the lilac blue is called *Amethyst*, and forms the passage to the sapphire. The crystals are mostly small, and when not worn by rubbing, have a brilliant external lustre. It varies in transparency; and in hardness ranks the third of all known substances, yielding only to the diamond and sapphire, nor will the most intense heat affect its colour or transparency. The ruby is found in the sand of certain streams near Syrian, the capital of Pegu; and also with sapphire in the sand of rivers in Ceylon. Rubies perfect in colour and transparency, of three or four carats, and upwards, are less common and more valued than diamonds.

The SAPPHIRE ranks next in value to the ruby, and is found chiefly in Pegu and Ceylon, in crystals not large, yet larger than the ruby. It is the hardest body next the diamond; and when perfect, its colour is a clear and bright Prussian blue, united to a high degree of transparency; but it very seldom occurs in this state, for often the colour is a pale blue, passing gradually from blue and red through numerous tints into bluish white and colourless; and not seldom are the pale varieties further deteriorated by dark inky blue streaks and spots.

The finest sapphires, like most of the gems, come from the East Indies. Russia does not produce the sapphire. In Scotland they are found of a hardness and lustre equal to the oriental, both light and deep coloured, at Benachie, and Invercauld, Aberdeenshire; Portsoy in Bamffshire, and many other places.

The pale varieties, when highly ignited, become wholly colourless; and hence, when cut and polished, have often been sold for diamonds. Another variety is the Asterias, or *Star Stone*, semi-transparent, often of a reddish purple tinge; and the secondary planes present a varying chatoyant* lustre. Cut *en cabochon,* or elliptical, with its summit exactly over that of the rhomboid, causes the appearance of a star with six rays, whence issues, held in sunshine, a yellowish white light, in beautiful contrast to the rich purplish blue of the other part of the stone.

The TOPAZ, next in value, is a very beautiful substance; the colour most esteemed is a bright jonquil yellow; then a pure lemon yellow; it is found in Brazil, Ceylon, Siberia, Cornwall, &c. in granite rocks, from a pale wine yellow to sky blue, and crimson (the latter often called *Brazilian rubies*); the fuller the colour, the more estimable the stone. By exposure to heat, the yellow topaz of Brazil becomes red, and that of Saxony white; proving their colouring matter to be different; but this experiment is hazardous, as the topaz is liable to crack and flaw by the heat. The largest ever known was in the Museum of Natural History at Paris, in weight about four ounces and a quarter.

The blue topaz (Brazilian sapphire,) is of recent introduction; in size from two or three carats to three ounces and upwards. The largest and finest specimen, cut and polished, weighed an ounce and quarter. The white topaz is colourless, and considerably exceeding rock crystal in lustre; it is much esteemed in Brazil, (called *minas novas*); is mostly of small size, and is used in circular ear-rings, or to set round yellow topazes.

The AMETHYST is of various degrees of intensity, often in the same specimen passing from the richest tinge to little if any colour. When complete in transparency and the depth, richness, and uniformity of its colour, it is much valued, and of exquisite beauty. It is the only coloured stone that can be worn with mourning. It is sometimes used as a ring stone, but may be had of any size for wearing. The most splendid use of it is as necklaces; the finest known was among the jewels possessed by her late Majesty Queen Charlotte.

The CHRYSOLITE is found in Brazil, Ceylon, Siberia, and Egypt; of a mixed colour of blue and yellow. It is principally found in angular and rolled pieces; and is the least hard of the gems; yet is sometimes worked

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* Changeable light, as seen in the eyes of cats.

up into necklaces, and similar ornaments; and when well matched and cut, the effect is very fine.

In the PERIDOT, two or more colours occasionally occur in the same crystal; thus, in the Greville collection at the British Museum, is a specimen blue and red at the two extremities, and yellow in the middle. Such specimens convince mineralogists how little dependence is to be placed on mere colour, in characterizing mineral species. The names topaz and chrysolite are changed in modern use from the ancient, for each other. The peridot is found in Upper Egypt. The Emerald Island in the Red Sea, mentioned by Bruce (who says, the green substance he found there, was scarcely harder than glass), is thought to be the Topaz Island of Pliny; and the body in question a chrysolite. The LEUCITE, is of a greyish white and orange (hence called the white garnet); it is usually found in volcanic productions, and is very abundant in the neighbourhood of Vesuvius, in crystals of various sizes, from that of a pin-head to that of an acorn.

The GARNET is found in Bohemia, Ceylon, and other countries; but the chief mart formerly being Syrian, the capital of Pegu, in India, the best are often denominated Syrian garnets. The colour most esteemed is blood or cherry red; mixed often, however, with blue, forming tints of crimson, purple, and reddish violet; or orange red, and hyacinth brown. The Syrian garnet is most esteemed; being of a violet colour, which, in some rare specimens makes it compete with the amethyst, (from which it is to be discriminated by the disadvantage of losing its brilliancy, and acquiring an orange tinge by candle-light); distinct from all other garnets, it preserves its colour unmixed with the common black tinge, unassisted by foil, even when thick.

Oxide of iron colours all the gems except the ruby, whose beautiful red is owing to a sixth of it being chromic acid. It is almost certain that too much oxide of iron alters the properties of the gems, and gives them a reddish colour, as seen in the garnet; while a small proportion is sufficient to colour them entirely, without injuring their play and splendour. In fact, their perfection depends less on the quality of the component principles, than on their complete solution and intimate combination. The alkalized earths, as lime, magnesia, and still better potash, seem to intervene as solvents; for alumina completely dissolved, acquires a crystallization, of which, by itself, it is not susceptible.

Gemmoids may be called degenerated gems. Alumina abounds only in *Corundum*, and *Adamantine Spar*, a species which forms the transition; in the *Sommite* and *Leucolite*, it is in the same quantity as silica, which exceeds in the *Olivine;* magnesia is found in the *Ceylanite*, lime in *Granatite*, and much barytes in *Andreolite* and *Staurolite*. Gemmoids contain more of the oxide of iron than the gems, and their colours are more confused, and qualities less esteemed.

CORUNDUM is of a greenish white colour, and found in India, Ceylon, and China. In 1768, Dr. Anderson having sent a box of it from Madras to Edinburgh, Dr. Black first discriminated it from other minerals, and it was called ADAMANTINE SPAR, (the proper name of another body found in China, of a dark brown colour, which is the only distinction). Mr. Greville, of London, in 1784, obtained specimens from India, with its name *Corundum;* and he and Count Bournon regarded it as a variety of sapphire.

The SOMMITE, found at Somma, usually mixed with volcanic productions, is of a greyish white. The LEUCOLITE is of various shades, from greyish white to peach blossom; it is found in Saxony, and was the second stony mineral remarked to contain the fluoric acid. OLIVINE occurs chiefly in basalt, and is common; of a yellowish green colour, usually in roundish grains, though sometimes crystallized. The CEYLANITE (from Ceylon), was first described by La Metherie, in 1793; its colour is dark blue, and it occurs usually in masses. The GRANATITE is found in Galicia and in Brittany, of a dark reddish brown; and by the French and Spaniards called *Cross Stone,* because in tabular crystals its prisms intersect each other at right angles, forming a cross. The ANDREOLITE and STAUROLITE, of a greyish white, occur in veins at Hartz and Strontian, and at Oberstein in crystallized agate balls.

The characters of the gems are a degree lower in the *Schorls,* a sort of crystals with tolerably fine colours, some splendour, and little hardness. The schorls differ little from each other; silica and alumina constitute their greatest part, and the former exceeds in all except the *Tourmaline,* the type of this class. Also oxides of iron and manganese, a twentieth of lime in *Pyroxenite* or schorl of volcanos, and *Amphibolite* or black schorl, which last contains some magnesia. Most of them are pyro-electric, which seems connected with volcanic phenomena; and schorls are mostly found among volcanic products. The other varieties best known are, the *Daourite,* or Siberian red schorl; the *Zeolites,* the *Axinite* or violet schorl; and the *Actinite.* The beauty of stones decreases as their composition becomes complicated, as the oxides increase, and as the alumina is absorbed, at first by the silica, and afterwards by the lime and magnesia—earths susceptible of alkalization.

The *Schists* are another considerable family of argillaceous stones. They are compounds in which alumina and iron always enter, but mixed with many of the other earths. Hence we find *argillaceous schists*, the common schists; *quartz schists*, or whetstone, which, because of their hardness, are used to sharpen iron; *magnesian*, or horny *schists*; *calcareous*, *barytic*, and *ferruginous schists*, or slates.

The ARGILLACEOUS SCHIST is less hard and weighty than the ferruginous, adheres to the tongue, and softens in water; its colour varies from yellow to brown, red, and spotted; very widely diffused; and sometimes forming entire mountains, as among the Andes, and in other metallic regions. The species which is met with in the Cordilleras, is of a blue cast; but it is of various beautiful colours, or mottled with various illinitions.

The QUARTZ SCHIST, or whetstone, is often of the cameo kind, or disposed in layers of different colours, the upper of a whitish yellow, and the under of a reddish grey; the first being of a finer texture; while the latter seems to graduate into the stone used to sharpen scythes. *Hones* are found in the mountains of Jura, and the Vosges: and the substance was found on digging a very deep well at Hampstead, near London. The finest are said to be brought from Turkey; but very good hones are found near Namur, in Flanders; also in Saxony, Siberia, Stiria, and at Laurenstein, where they are wrought. They usually present two layers, the upper of a pale greenish yellow, and the under of a dark brown.

The MAGNESIAN SCHISTS are of different colours, found in Scotland, Sweden, and Norway; and are of a very silky appearance and touch.

The CALCAREOUS SCHISTS present alternate layers of different colours, as white and red, and white and green. The species obtained at Pappenheim, in Germany, rises from the mine in thick tables, serving for pavements, gravestones, &c. At Stonesfield, near

Woodstock, is a large mine; and the schists are easily separated into laminæ, by mechanical means, and even by the action of the atmosphere. They are mostly employed for the roofs of buildings; and their separative property depends on their proportion of clay, and the nature of its deposition. Some parts contain numerous minute shells, resembling millet seeds; their deposition being more abundant on the surface, than in the substance, of the schists. In some instances, oxide of manganese causes a singular black arborescent appearance, on the contiguous surfaces of adjoining laminæ; similar to what is observed in some varieties of Florentine marble. There are mines of these schists, called FLAGS, in Lancashire, Yorkshire, and Derbyshire.

The FERRUGINOUS SCHIST, or, better denominated, *Slate*, can be easily slit into very thin plates, having a blackish blue colour, and impenetrable, because of their quantity of iron; of several varieties, found in Cornwall, Wales, Westmoreland, and Scotland; also in most other parts of Europe, and in America.

Near Liskeard are several slate quarries, which supply the inhabitants of Plymouth with covering for their houses, and for exportation; but the best covering slate, probably in England, is at the quarry of Denyball, near Tintagel, in the north of Cornwall. The quarry is 300 yards long, 100 broad, and 80 deep. The dip of the rock has a south-west inclination, in strata first found about a yard below the soil, in a loose, shattery state, with short fissures, the laminæ of unequal thickness, not horizontal, for 10 or 12 fathoms, when a firm and useful stone is procured, of which the largest pieces are used for flat pavements. This is called the top-stone, for 10 fathoms; after which the quality improves with the increasing depth, till, at 24 fathoms from the surface, is found the bottom-stone, of very superior kind, of a grey blue colour, and so fine a texture, as to sound like a piece of metal. The masses, of from 5 to 14 superficial square feet, are separated from the rock by wedges and iron malls; and as soon as the mass is freed by one man, another stone cutter, with a wide chisel and mallet, is ready to cleave it to its proper thinness, about the sixth of an inch; the pieces being mostly from a foot square, to two feet long by one wide, though at times, the flakes are sufficiently large for tables and tomb-stones.

Patrin informs us, that the slate quarries of Charleville in France, are not explored by open quarries, but by subterranean galleries. The principal mine is that of Rimogne, in a hill, the mouth towards the summit. The bed explored, which the workmen call the Plate, because of its thin and flat form, has an inclination to the horizon, of 40°; 60 feet thick, and its limits unknown, though it has been pursued by a principal gallery 400 feet deep, and many lateral ones on each side of it, above 200 feet; with 26 ladders, placed in succession, for the passage of the workmen, and conveyance of the slate. But of the 60 feet, only 40 are good slate; of an excellent quality, and deep blue colour. —To quarry these slates, they cut out blocks, called *faix*, about 200 pounds in weight; which each workman, in his turn, carries on his back, with infinite labour, up the ladders, according to the depth, to the mouth of the mine. There the workman holds the block between his legs, and with a chisel put any where to the side, with the stroke of a mallet, easily splits it into *repartons*, afterwards treated similarly, till of the requisite thinness.

CLAYS form the last family of the Argillaceous genus, and present several varieties, as *common clay, potter's clay, pipe clay, lithomarge, mountain soap*, &c. all containing more or less oxide of iron and silica. Aluminous stones are also found, similar to a whitish hardened clay, whence alum is extracted.

At Halle, in Saxony, is found a species called PURE CLAY, of a snow white colour, and fine quality. Common Clay, used for bricks, &c. is very impure, mixed with mica, and iron ochre; of a yellowish grey and brown colour, and not heavy. POTTERS' CLAY occurs in separate strata, or beds, of a smoke grey colour; while PORCELAIN CLAY sometimes constitutes rocks, but is merely decomposed felspar. When of a greyish white, it is called PIPE CLAY, of a light nature,—all adhering to the tongue, and being greasy to the touch. The noted *Kaolin* of China, the chief ingredient in their porcelain, is decomposed felspar, from an entire rock, (called *Petuntze*) as it is without quartz; and that of Limoges, in France, the chief ingredient of the Sevres porcelain, is decomposed granite, whence the grains of quartz are very carefully separated. The clay of which the Egyptian vases have so long been formed, is of a marly nature, fawn colour, and a porous and light consistence, found near Coptos, in the Thebaid. Porous vases, which, by evaporation, impart great coolness to water, are made also in Spanish America.

The ALUM ROCK at Tolfa, where *roche* alum is made, was discovered by a person who had escaped from captivity in Turkey, where he had worked in some alum works. Ferber says,

"The Alum Hills, at Tolfa, are very high, shining, white rocks, separated by a long valley, and large excavations, thus made:—the workmen descend to the steep rocks by ropes; then bore blasting holes, fill them with cartridges, free the rocks by former blastings loosened, and are then pulled up. The powder is fired by dry branches and leaves, which they can throw from on high, to any place below. The rock is whitish grey, extremely compact and hard. Scraped with a knife, it yields a powder, not fermenting with any acid, being argillaceous, and penetrated by vitriolic acid. Some bluish grey shivery pieces are rejected; (probably the remains of the natural argillaceous stone, not sufficiently whitened by imbibing the vitriolic acid.) In some cracks is a chalk-white ductile clay. Some pieces are blueish grey, with white spots, caused by the acid: much like the half dissolved black lava in Solfaterra, with white garnet-like schorls; only thus differing—in Solfaterra, the acid worked on lava; here, on a blueish argillaceous stone. The acid here seems produced by subterranean steams penetrating, and changing the argillaceous stones into alum ore. The aluminous rock appears to be an indurated clay, imbibing, and whitened by vitriolic acid, and containing some calcareous particles, which precipitate a selenites in the troughs of the alum manufactories.

The blasted stones are calcined in furnaces with an inverted conical form, the upper diameter being about eight feet, in the open fields, separated only by a surrounding covering of turf and mould. Some wood is put at the bottom, on which is heaped alum-stone, in a rising cone, above the mouth, 9 or 10 feet high, same as the depth. The wood is fired by a vent, near the bottom, and the whole is burned in about three hours; when the heated stones are carried about one Italian mile, to the boiling-house, and put into large square wooden reservoirs, half sunk in the ground, with a suitable quantity of water for steeping, and dissolution, which is then conveyed into large square wooden settlers, wherein the dregs fall to the bottom. The clear lixivium is then boiled sufficiently, in brass pans, after which it is conveyed into wooden coolers, and the alum crystallizes red and white on the sides."

Silicium is the metallic base of the *Silicious genus*, which follows the Argillaceous; and are the most common elements that enter into the composition of stones. This genus offers four families; *Quartz, Silex, Hornstone,* and *Petrosilex.*

QUARTZ, very abundant on the globe, is mostly found in irregular masses, with polished facets, and of all colours, possessing transparency, brilliancy, and hardness. Sometimes quartz, purified in its principles, appears in a regular rhomboidal form, similar to gems, from which it differs only by less hardness, weight, play, &c. Such is ROCK CRYSTAL, (sometimes abroad mistaken for diamond, and some of the most brilliant crystals found in Ireland, and Cornwall, often get the appellation; while the coloured varieties, according as the teints resemble real gems, take the name of *false topaz, false ruby, water sapphire,* and *amethyst;*) imitating the nature of the diamond, by its perfect transparency, and the purity of its crystallization.

The clearest and most esteemed ROCK CRYSTAL, comes from Madagascar, in blocks of from 50 to 100 pounds weight; in Switzerland, and in Auvergne, very fine specimens are procured; and inferior ones, for size or clearness, occur in almost every part of the world.

The *yellow* specimens are called FALSE TOPAZ, (*Topazine Quartz,* and *Smoke Quartz;*) often, in intensity, equalling the Saxon topaz, yet very inferior to that of Brazil.

The FALSE RUBY, as yet little known to jewellers, is Rose Quartz, of a very beautiful pale pink colour, and far superior to rock crystal, as an ornament.

SILEX resembles the argillaceous genus; the characteristics decrease, in proportion, as the quantities of silica and alumina are more equal; as in the family of SILEX, distinguished from the quartz, by their undetermined form, slight transparency, and milky aspect. Thus, the silex is to rock crystal, what the gemmoids are to the gems; and their comparative value is similar. The chalcedonies, agates, heliotropes, cat's eyes, opals, girassols, hydrophanes, frissites, jaspers, and menilites, (all to silex, what rock crystal is to quartz,) are much esteemed, because of their singularities, and their utility in the arts.

The CHALCEDONY is found in Cornwall, Scotland, Iceland, India, Arabia, Hungary, Saxony, and the Faro islands, mostly amorphous, or in rounded masses, but sometimes in pseudo-crystals, of varied grey colour: the *smalt blue* variety is the rarest, and most esteemed.

The AGATE is found in various parts of Britain, and Ceylon, of varied colours, hardness, and lustre. Near Dunbar, in Scotland, are found those beautiful granular concretions, called Scots Pebbles, admired for their concentric zones, of delicate colour and exquisite polish, when formed into brooches, necklaces, &c.

The concentric agates with zones very distinct, and colours strongly contrasted, are generally called ONYX, and when large, are highly prized. Those with alternate bands of green and white, and red and white, are in high estimation. But those in which plates of sarde alternate with others of nearly opaque white carnelian, are the most beautiful, and very highly valued; and are called *sardonyx.*

The CAT'S EYE comes from Ceylon, is in general less than a hazel nut, but rarely seen by European mineralogists before polished by the lapidary. The colour is various, yellow, green, and even red; and in certain positions, when cut in high *cabochon,* it reflects a peculiar white splendid light, resembling the eye of a cat; its texture is so compact that its foliations are scarcely discernible; it will strike fire with steel, being as hard as rock crystal, but easily frangible.

The OPAL is found in many parts of Europe, especially in Hungary, and small rounded pieces of it occur in the sand of Ceylon: it is of a milk white, or pearl grey colour; and when placed between the eye and the light, emits various rays, with beautiful effulgence, as pale rose red, or wine yellow, with a milky semi-transparency; the colours being more bright and splendid, because they are not occasioned by any particular tinge of the substance, but by its peculiar property of refracting the solar rays.

JASPER occurs, like chalcedony, in veins, in different parts of Europe and Asia; it is hard, compact, and takes an exquisite polish; of varied colours and kinds; opake, and sometimes the colours appear in stripes, bands, dots, and flames. The striped green and brown Siberian jasper possesses great beauty; but the Egyptian is chiefly used for brooches and beads.

The HORNSTONES have only a very feeble semi-transparency, and an aspect like that of horn. The *hornstein* of the Germans (*chert* of England), is the type of this family; its analysis gives only eighty parts of silica, and twenty of alumina; consequently it never crystallizes, and has no determinate colour.

The stones called *petrosilex,* real proteuses, of which it is difficult to fix the characters, connect themselves, by their numerous modifications, to all the genera of stones. The true petrosilex is composed of seventy-two silica, twenty-two alumina, and six lime, having in an inferior degree the characters of the silex. Sometimes oxide of iron and magnesia are joined with it, producing a sort of siliceous schist; sometimes carbonated and sulphurated lime, oxide of iron and water, as in the LAZULITE, found in quartz at Vorau in Stiria, of a blue colour, massive, feebly translucent, and easily frangible; and the LAPIS LAZULI (*azure stone*), found in limestone rocks in Persia and China, is of a glistening lustre, and feebly translucent; it is also blue; never crystallized, harder than glass: hence it is often made into brooches, and *ultra-marine* is formed from it.

Hitherto diamonds have been observed in the torrid zone alone; and Brazil is the only part of the Americas in which they have been found. The historical account of their discovery in that country is as follows: near the capital of the territory of Serro do Frio flows the river Milho Verde, where it was the custom to dig for gold, or rather to extract it from the alluvial soil. The miners, during their search for gold, found several diamonds, which they were induced to lay aside in consequence of their particular shape and great beauty, although they were ignorant of their intrinsic value.

The diamond works on the river Jigitonhonha are described by Mr. Mawe as the most important in the Brazilian territory. The river, in depth from three to nine feet, is intersected by a canal, beneath the head of which it is stopped by an embankment of several thousand bags of sand, its deeper parts being laid dry by chain-pumps. The mud is now washed away, and the *cascalhao*, or earth which contains the diamonds, dug up, and removed to a convenient place for washing. The process is as follows: A shed, consisting of upright posts, which support a thatched roof, is erected in the form of a parallelogram, in length about 90 feet, and in width 45. Down the middle of its area a current of water is conveyed through a canal covered with strong planks, on which the earth is laid to the thickness of two or three feet. On the other side of the area is a flooring of planks, from 12 to 15 feet in length, imbedded in clay, extending the whole length of the shed, and having a gentle slope from the canal. This flooring is divided into about 20 compartments, or troughs, each about three feet wide, by means of planks placed on their edge; and the upper end of these troughs communicate with the canal, being so formed that water is admitted into them between two planks about an inch separate from each other. Through this opening the current falls about six inches into the trough, and may be directed to any part of it, or stopped at pleasure, by means of a small quantity of clay. Along the lower ends of the troughs a small channel is dug, to carry off the water.

On the heap of earth, at equal distances, three high chairs are placed for the overseers, who are no sooner seated than the negroes enter the troughs, each provided with a rake of a peculiar form, and having a short handle, with which he rakes into the trough from 50 to 80 pounds weight of the earth. The water being then allowed to pass in by degrees, the earth is spread abroad, and continually raked up to the head of the trough, so as to be kept in constant motion. This operation is continued for a quarter of an hour, when the water begins to run clearer; and, the earthy particles having been washed away, the gravel-like matter is raked up to the end of the trough. At length the current flowing quite clear, the largest stones are thrown out, and afterwards those of an inferior size; the whole is then examined with great care for diamonds. When a negro finds one, he immediately stands upright, and claps his hands; he then extends them, holding the gem between the fore finger and the thumb. When a negro is so fortunate as to find a diamond of the weight of 17 carats and a half, the following ceremony takes place: he is crowned with a wreath of flowers, and carried in procession to the administrator, who gives him his freedom by paying his owner for it. He also receives a present of new clothes, and is permitted to work on his own account. For smaller stones proportionate premiums are given; while many precautions are taken to prevent the negroes from stealing the diamonds, with which view they are frequently changed by the overseers. When a negro is suspected of swallowing a diamond, he is confined in a solitary apartment, and means taken to bring the gem to light.

LECTURE XXVII.

ON THE MOUNTAINS.

There Winter, armed with terrors here unknown,
Sits absolute on his unshaken throne;
Piles up his stores amidst the frozen waste,
And bids the mountains he has built, stand fast,
Beckons the legions of his storms away
From happier scenes to make the land a prey;
Proclaims the soil a conquest he has won,
And scorns to share it with the distant sun.

Although the earth at the distance of Venus, or even at the smaller distance of the Moon, would appear to be a perfect sphere, yet those bodies, when examined with a telescope, like the earth, exhibit great inequalities. Nevertheless, in such a mass as the earth, the mountains subtract less from its spherical figure than the roughness on the rind of an orange subtracts from its sphericity. For, although few mountains on the earth are four miles high, that elevation is but the two thousandth part of the diameter; and the roughnesses on an orange being taken at the hundredth part of an inch, and the orange at three inches, those roughnesses are the three hundredth part of the diameter, and in proportion six times greater, with reference to the whole orange, than the highest ridge of mountains is with reference to the earth. Such being the case in regard to the ridges of the Himalayas in Thibet, and the Andes in South America—the Alps, the Pyrennees, and the mountains of Scotland and Wales, sink into comparative insignificance.

The formation of mountains is a subject of difficulty. If the sea now flowed over the countries in which they are situated, they would constitute chains of islands in those seas; and from what we know of the depth of soundings round St. Helena, and other islands, we may consider them as mountains rising from the bed of the present ocean. The circumstance that marine remains are found at great elevations in mountains, demonstrates beyond the possibility of doubt, that the sea must have flowed for many ages at those elevations. But the apexes seem by their structure to have constituted parts of the original crust of the earth; unless indeed we are to suppose that in all instances they are volcanic, and have been raised to their present heights by discharges of lava, and the scoriæ of internal local fires. This last seems to be a probable supposition, and in that case mountains must be regarded as the work of time. When raised, the returning action of the sea at their base may have undermined them, and we may probably ascribe to their overthrow many surprising irregularities which appear on the surface of the earth.

With regard to the formation of minor hills and valleys there seems no difficulty in ascribing them to the action of water. For it is a well-known fact that successive tides, acting on the loose shingle and sand on the shores, press the base of any elevation in such manner as constantly to raise it higher and higher above the water; insomuch that the sea thus forms its own banks and boundaries. Almost every coast presents instances of these formations, but they are particularly conspicuous in the sand hills on the coast of Flanders, where a line of sand hills has palpably been forced up and gradually accumulated by the sea, to the height of one or two hundred feet above its level. Hence, it is not even necessary that recurring tides should actually overflow a country to form its hills and inequalities.

The most striking circumstance in the structure of rocks is their disposition into strata or layers, placed one above the other, sometimes thick, but sometimes so thin, as to present the appearance which we call *slate*. This stratified structure deserves notice, not only in itself, but as affording an index to the early formation of the globe; since it can only be accounted for by the supposition of these rocks having been deposited from water. A great proportion of rocks, however, are unstratified, and their parts are arranged sometimes in globular or columnar masses, but more frequently with perpendicular and cross rents, giving to the face of such rocks the appearance of stairs, whence mineralogists have applied to them the appellation of *trap*. These original formations are variously traversed by foreign substances in the form of *veins*, which exhibit many curious phenomena, and in which the more valuable metallic and mineral substances are usually found incorporated.

The low land of the globe may be divided into vallies and plains. The vallies or river districts consist of a hollow tract, often bordered on each side by mountains or hills, and at the bottom of which runs the river, into which a succession of tributaries usually fall. The extensive vallies, traversed by great rivers, are commonly the finest and most beautiful regions of the earth. Large plains, neither diversified by mountains nor rivers, are often found, especially under the torrid zone, to labour under the want of moisture. Hence immense tracts are found covered either with loose sand, or with a hard and impenetrable clay, both equally unproductive of any valuable vegetation.

In the mountain districts, the most conspicuous feature consists in the rocks of which they are composed; but a full investigation of their structure and component parts has already been given in this work.

Mr. Jameson observes, that the form of every mountain depends upon the species of rock of which it is composed, and is not affected by any other circumstance. Granite, when exposed, exhibits high and steep cliffs, sometimes vast mural precipices, and often shoots up into those lofty and precipitous summits, which are denominated *peaks*. This steep and rugged character is less conspicuous in gneiss, and still less in mica slate, while in clay slate there appear only smooth and round backed mountains, without cliffs or precipices. The earlier limestone presents rough cliffs, immense mural precipices, narrow and deep valleys. The later, or floetz limestone, forms extensive tracts of flat country, intersected by narrow and deep valleys, sometimes by rocky cliffs and tremendous rents. Fragments of rock falling into these valleys, and being cemented by calc finter, form large caves, which accompany this limestone in every part of the globe. These caves abound in the mountains of Germany, particularly in the Julian Alps.

Sandstone usually forms mountains of secondary magnitude; but in consequence of the softness of its composition, which causes it to be easily acted upon, and partially broken down by external causes, no rock presents so great a variety of form. This is peculiarly conspicuous in the latest formation called by Werner the third sandstone. "Its valleys (says Mr. Jameson) are deep, rocky, and romantic; its hills conical, steep, and cliffy; and it often presents grand colossal pillars and masses, which, from their number and the variety of their shape, form most striking rocky scenes." In several parts of Africa, and in Russia along the Wolga, these rocky masses present, at a little distance, the appearance of large cities in ruins; and they have sometimes, by superficial travellers, been described as such.

We shall now proceed briefly to enumerate the principal chains of mountains, which may be ranked amongst the most stupendous phenomena of Nature, and of which we have presented a comparative view, in *the Engraving*.

In Europe we find but two high lands and one low land. The one is the great European or southern elevation of the Alps and Pyrennees, the other the Scandinavian or northern elevation in Sweden and Norway. The one has its middle point in Switzerland, in the Tyrol, and in the Alps of Savoy. Hence it passes through three-fourths of France, traverses the whole of Portugal and Spain, includes nearly two-thirds of Germany, passes through the greater part of Italy, and also part of Hungary and Turkey, and terminates on the borders of the Black Sea. The course of this high land determines that of the great low land. Saxony lies nearly on the border of this low land or plain. It passes through the north part of Saxony, to the east or Baltic Sea. It also passes by the foot of the Alpine mountains, through the upper part of Westphalia, and further through the whole of Holland, the Netherlands, and a small part of France; it even reaches the east coast of Britain. It extends very considerably towards the north, including in its course Prussia, Poland, and nearly all Russia in Europe, and reaches to the Uralian mountains, including the greater part of Moldavia. The other mass of high land lies in Norway and Sweden, and presents a dreary and inhospitable aspect. If Europe were to be modelled, or seen at the distance of the moon, it would therefore present two masses of hills, and extended plains lying between them, with various sinnosities among the mountains.

THE PYRENNEES:

Here, 'midst the changeful scenery, ever new,
Fancy a thousand wond'rous forms descries,
More wildly great than ever pencil drew;
Rocks, torrents, gulfs, and shapes of giant size,
And glittering cliffs on cliffs, and fiery ramparts rise.

Spain, almost separated from Europe by the Pyrennees, would have the soil and climate of Africa, were it not intersected by high mountains, whence flow numerous rivers, which rise from several chains of mountains that go off from, and run parallel to the mass of the Pyrennees. Their granite base supports calcareous and schistous blocks, whose summits are indented like a saw, thence named *Sierra.* Some summits are lofty, and ever covered with snow; others are steep rocks without any earth, like the mountains of Portugal.

The mass of the Pyrennees is very steep; the valleys are transversal in an opposite direction, joining by their upper part in the intervals between the peaks. Here, from narrow passages opened at immense heights, the eye plunges on the plains, watered by the Ebro and Garonne. A perpendicular wall rises as the boundary between Spain and France, with an abrupt interruption, where the rocks curved like an arch open and form a colossal gate called *Breche de Roland.* It serves as a support to the circus of *Marbore,* 1400 feet high, and crowned by towers whose battlements are hidden under continual snows. From the battlements twelve torrents rush, and from range to range proceed with foaming waves to the bottom of the circus. This is the fall of the *Gave,* one of the most considerable in the world. Its waters force a passage below the continual snows, and often the natural bridge sinking under its own weight, its ruins are borne along by the torrent, which increases the uproar. When the torrent reaches the picturesque valley of Barrege, the steep rocks afford many mineral waters, which, mixing with those of the Gave, fertilize the meadows of Bearn.

The composition of the Pyrennees is remarkable; every peak being a *nucleus* of aggregation, and the great chain an assemblage of intertwisted links connected by their base. The peaks are seldom central in their links, but incline southward. All are of gra-

THE ALPS (from BERNE)

nite; in some entire, in others with salient bands, and some times with great crystals of felspar. These *nuclei* have a powerful effect, as the crystallization of the rocks decreases in the ratio of the distance from the main peak; hence the rocks of first and second formation constantly alternate; and as each link does not equally partake the direction of the great chain, the latter is, on several points, traced by the stratified rocks which terminate the crest in diversified curves.

The highest summits are Canigou, Piedu Midi, and Mont Perdu, which last is 10,578 feet high. The glaciers begin at 1200 toises above the sea, and are of moderate extent; perhaps because the mass is not very broad, or highly elevated; or the vicinity of the two seas keeps up a humidity which renders the ice less permanent. The great drains of water are on the French side. The *Ande*, and some less considerable rivers, run east towards the Mediterranean, after traversing the elevated plains of Bearn and Roussillon. The Garonne and its numerous feeders run west; at first it is a torrent, falling in cascades from the *Montaigne Maudite* into a basin 80 feet deep which it has hollowed out of the calcareous rock, which terminates the valley *Artigues Telline;* a grotto opens, the torrent escapes through, mixes its waters with those of the valley of Aran, and is then called Garonne. Its basin is a vast plain, sloped north-west, terminating in the gulf of Gascony. The soil is light, with sandy tracts on each side the river, which reaches the sea by a broad mouth, up which the tide ascends very high.

THE ALPS.

Again, where Alpine solitudes ascend,
I sit me down a pensive hour to spend;
And, placed on high above the storm's career,
Look downward where a hundred realms appear;
Lakes, forests, cities, plains extending wide,
The pomp of kings, the shepherd's humbler pride.

The Alps begin beyond the Var, near the Mediterranean; ascend north to the Valais; to the east they form a buttress to Helvetia, stretch circularly in the Illyrian provinces, and advance to the Adriatic near Trieste and Fiume. Mont Blanc, west of the Valais, is the prop of the chain, and also the most elevated summit, being 14,880 feet above the level of the sea. From its chain extend colossal needles, semicircularly, like an immense coliseum; to the west the Col du Geant, Mount Cenis, Rock Nelson, and Mount Viso. East, are the peaks of Argenterie and Midi, Great St. Bernard, Simplon, Mount

Arvin, St. Gothard, the Pic de Tempeles, the Septimer in the Grison, the Ortelor in the Tyrol, and the Terklow in Carniola.

The Alps have few intertwisting links; only two joining St. Gothard, whose duplex composition is proved by the unequal distribution of the metallic rocks, less common than in the Pyrennees. Gold and copper lie westward; and iron, lead, and mercury, in Styria and Carniola. The valleys are longitudinal, the branches go off at right angles; except the Valais, which stretches parallel to the mass. The granite is of the same nature as in the Pyrennees, but in the Alps it is disposed in immense layers, or vertical superimposed banks.

The tops of the Alps are covered with snows, and immense glaciers spread in their intervals, sometimes continued from one valley to another, on the declivity of the summits, as in that of Gries, which separates the Valais from Piedmont. But at the glaciers of Grindelwald and Bois, in the vale of Chamouni, these magic pictures and sublime horrors may be admired. From an insulated summit, the eye plunges on a sea of ice, whence arise crystalline blocks, transparent walls, prismatic needles confusedly intertwined, and resembling a storm arrested in its fury. The brilliant reflexions, the colours of the rainbow, and lights infinitely diversified, enliven this view, where the objects are confounded and again separated as if supernaturally.

> So pleased at first the tow'ring Alps we try,
> Mount o'er the vales, and seem to tread the sky;
> Th' eternal snows appear already past,
> And the first clouds on mountains seem the last:
> But, those attain'd, we tremble to survey
> The growing labours of the lengthen'd way;
> Th' increasing prospect tires our wand'ring eyes,
> Hills peep o'er hills, and Alps on Alps arise!

The depth of the glacier of Bois is 100 feet; bordered by a kind of parapet called *moraire*, a heap of sand and fragments which have fallen, and advance sometimes towards the middle of the basin, by the annual retreat of the ice. The origin of these glaciers is this,—the snow covers the summits of the mountains, whence detached, and drawn by the avalanches, or falling to the bottom of the valleys, it accumulates. During the summer the surface thaws; the cold returns and converts the whole into ice. Some

MONT BLANC from the Valley of CHAMOUNI.

increase, as that of Grindelwald, which has advanced beyond a bridge formerly frequented; but others decrease, yearly, as that of the Rhone. These glaciers feed numerous rivers, whose course is determined by the divers branches from the mass; as the *Apennines* south, the *Cevennes* west, the *Vosges* north, and the *Noric Alps* east.

A branch stretches north of Mont Blanc, by the Jura mountains, connected with the Vosges, and terminated by Mont Tennere, near Mentz. In the Alps, most rocks shoot several hundred feet above the mountain, like obelisks, and are called *needles;* in the Pyrennees, vast masses of rocks present abrupt slopes and steep though accessible fronts, resembling large pyramids, and are called *peaks;* and in the Vosges they are called *balloons,* because of their round sloping forms, without the rugged aspect of the other chains; neither are there steep rocks, immense fissures, glens frightful from their depth, and incased so as to resemble enormous slits; here are none of those grand appearances which are so common in the high Alps;—but, in the Vosges, the valleys resemble arbours or bowers;—the gentle slopes of the hills, and convex summits, intimate their being tertiary mountains; while their component materials place them all as the most marked primitive mountains.

The chain of the Vosges, cutting that of the Alps at a right angle, forms two great basins opening north-west and north-east. In the centre of the first is the *plateau* Ardennes, dividing the waters towards the Seine and Meuse. The Ardennes, of less elevation than the Vosges, differ from them by their rugged aspect, and rocks intersected by ravines. No fossils are found here; the mass is chiefly argillaceous schists, traversed by veins of quartz, or interrupted by great blocks of granite; these schists sometimes turn into talc, but oftener into slate, and are every where penetrated by iron, copper, and lead. The beds of shells continue all round the *plateau,* and terminate on the borders of the Seine and Meuse. In the inferior part of its course, the latter traverses the vast plains of Flanders and Holland, formed of thick layers of clay mixed with sand and lime. Peat here supplies the place of coal; the marshes are almost continuous; the air is thick and moist; the fogs seldom disappear, and ice forms on the banks of the rivers.

The stone quarry at Maestricht is so immensely large, that 40,000 persons may take shelter in it, and Goldsmith says, it has been used for such purpose by the neighbouring people when armies have passed through that part. When lighted up with torches, the beauties of the scene surpass description; there are thousands of square pillars, in large level walks, about 20 feet high, all wrought with much neatness and regularity; there are also little pools of water in various parts.

The Apennines go off above Nice, circumbound the gulf of Genoa, traverse Italy, and by Calabria cross Sicily. The mountains of Corsica and Sardinia are not related to the Apennines. Their southern direction, and granitic nature, might intimate a prolongation of the Alpine chain. The elevation of the Apennines is much inferior, Mount Velino, in Romagna, the highest summit, being only 7872 feet, and the snow disappearing in June.

The side of the Apennines towards the Mediterranean is steep, with deep ravines, from Nice to the gulf of Spezzia. The plains of Tuscany begin there, and continue by Romagna to Naples, where the ground becomes hilly, especially in Calabria; divided near the Apennines, but marshy near the sea, as at Mareunna and Portrie. The *Arno*, (which falls into the Tuscan sea near Pisa,) and the *Tiber*, water this classical country, favoured by the finest climate, but subject to two scourges, the sirous and subterraneous fires. The former suffocates all that has life, and diffuses the burning air of the African coasts, that would change those of Italy into desarts, did it continue. The other often surprises the inhabitants amidst their employments, and buries them under the ruins of their superb edifices. Heaps of sulphur and bitumen, exhaling from flames; scorified hills, whence burst thermal and sulphureous waters; burnt stones scattered on all sides; plains covered with ashes and puzzolanas; torrents of lava from craters, forming causeways on the shores of the sea; every where present traces of successive destructions, of sudden changes, and terrible catastrophes, which announce the fatal influence of neighbouring volcanoes.

The valley of Solfatara, near Naples, exhibits on a small scale whatever is terrible in air, earth, fire, and water. The plain, about 1200 feet long, and 1000 broad, is embosomed in mountains, and has a central lake of noisome blackish water, whereon floats bitumen. In every part of the plain, appear caverns smoking with sulphur, and often emitting flames. The earth trembles under the footsteps; noises of flames, and the hissing of waters, are

Chamouni and the Icy Summits of the Alps.

heard at the bottom; the water sometimes spouts up eight or ten feet high; and the most noisome fumes, fetid water, and sulphureous vapours, often arise.

The mountains of our country are of an inferior rank; eastward are calcareous plains; and westward bands of granite, which, in Wales, support great masses of quartz and serpentine. Scotland presents mountains of granite, in great disorder, with phenomena of different sorts very common. England is rich in metals, especially tin. Immense deposits of coal are found, with mineral waters, and natural curiosities of every kind. The coasts in general are bordered by high rocks; the neighbouring isles are volcanic; while Ireland appears to have been the focus of innumerable subterraneous fires.

The loftiest mountain in Scotland is Ben Nevis; its elevation above the level of the sea being 4380 feet, more than four-fifths of a mile. It terminates in a point, and elevates its rugged front far above all neighbouring mountains. It is of easy ascent; and at the perpendicular height of 1500 feet, the vale beneath presents a very agreeable prospect, the vista being beautified by a diversity of bushes, shrubs, and birch woods, beside many little verdant spots. At the summit, the view extends at once across the island, eastwards to the German ocean, and westward to the Atlantic. Nature appears on a majestic scale; the vast prospect engages the whole attention, while the objects in view are of no common dimensions. At the south-west corner of Mull, Colonsay, distant more than 90 miles, rises out of the sea like a shade of mist. Shuna, and Lismore, appear like small spots of rich verdure, and, though almost thirty miles distant, seem quite under the spectator. The low parts of Jura are not discerned, nor any part of Isla, or the coast of Ireland. The wide extent of view, however, extends 170 miles from the horizon of the sea at the Murray Firth, N. E., to Colonsay, S. W. On the N. E. side is an almost perpendicular precipice, exceeding one third part of the entire height of the mountain. A stranger is astonished at viewing this dreadful rock, in whose bosom a quantity of snow lodges throughout the year. The sound from the fall of a stone thrown over the cliff cannot be heard; hence it is impossible to ascertain in that way the height of the precipice.

The peak of Snowdon, in Wales, is 3571 feet above the level of the Irish sea. Its summit presents a scene, magnificent beyond the powers of language. Indeed language is indigent and impotent when attempting to sketch with delight scenes, on which the Eternal has placed his matchless finger! Five and twenty lakes are visible; the eye, unaccustomed to measure such elevations, is puzzled in accommodating itself to scenes so wonderful. Rocks and mountains, which, observed from below, bear all the evidences of sublimity; when viewed from the summit of Snowdon, are blended with others as dark, rugged, and elevated as themselves; the whole resembling the swellings of an agitated ocean. Snowdon, rising in the centre, appears as if he could touch the south with his right hand, and the north with his left. The extent of the prospect is almost unlimited; the four kingdoms are seen at once—Wales, England, Scotland, and Ireland, forming the finest panorama the empire can boast. The circle begins with the mountains of Cumberland and Westmoreland; Ingleborough and Penygent, in Yorkshire, and the hills of Lancashire, follow; then the counties of Chester, Flint, Denbigh, part of Montgomery, most of Merioneth, and the regions from the triple crown of Cader Idris, to the sterile crags of Carnedds, David, and Llewellyn. The eye glances over Cardigan Bay, reposes on the summit of the Rivel; sees in the extremity of the horizon the blue mountains of Wicklow, gradually lost to the sight, which tired reposes on the Isle of Man and the distant mountains of Scotland.

The *Hemus* chain spreads through Greece and Turkey; it is more complex than the Pyrennees, and more simple than the Alps, yet differing from both in its contracted base, slight elevation of summits, extreme division of its branches, and the absence of glaciers and large rivers. It merely completes the chain of the Alps, east; and accompanies the great valley of the Danube to its termination.

The whole southern slope, from the Adriatic to the Black sea, is steep, with few large rivers, but numerous springs. Its interposition protects Greece from the north winds, and keeps off the cold of the Alps and the heat of Africa. Here, all depends on the exposure of places, climate varying in the neighbouring valleys. The winter is sharp in the high plains of Arcadia, Thessaly, Epirus, &c. yet every where the air is pure and salubrious.

The *Krapack* begins under the 50th parallel, between 13° and 14° east, and continues north of the Danube to 23°, where it disappears in the plains of Buckowine. At the two extremities, the chain curves, and stretches direct south. The west branch is *Sudetes*, the east *Transylvania*. This triple chain never attains the height of the Alps or Pyrennees, and seldom that of Hemus. The highest summits, Kriwan, Kesmarck, and Leumitz, are about

The Glaciers of Miage.

Devil's Bridge in the Alps.

4300 feet. The whole crest is granitic, with an immense bed of primitive limestone on its sides, in some parts replaced by argillaceous schist; in others the granite passes insensibly to gneiss and micaceous schist.

The *Fatra*, a group from the chain, projecting into Hungary towards Kreumitz, is argillaceous schist, containing thick metalliferous beds. In the chain of Scheumitz, east of Fatra, veins are numerous, and traverse porphyry and crystals of felspar. Abanatic cone rises high :—the Calvaribergs with vertical beds and ramified veins. More south, the metals lie in beds in greywack, or in veins in primitive trapp, resembling porphyry from being seeded with crystals of felspar. The Fatra reach the borders if not across the Danube, and the Bakoni mountains beyond, show some signs of volcanoes.

The western side of the Carpathian mountains for some distance maintains a high level, and then slopes rapidly towards the North sea. There also, are metals in abundance, furnished by the *Sudetes*, which extend through Bohemia, Saxony, Westphalia, and Hanover. Uranite is found at Georgenstadt in Saxony, and at Ioachimstadt in Bohemia. Bergstadel, in Bohemia, affords native antimony. In all these mountains, gold, silver, copper, bismuth, lead, &c. abound; but they are not equal to the Hartz, in Hanover, where nature seems to have collected all the species, and all the varieties of metals.

Many rivers flow from the Sudetes, into the Weser, a rapid stream, varied with cataracts, and often obstructed by ice. Some of its feeders come from Westphalia and Hesse, a hilly country, on one side leaning against the Alps, between the Danube and Rhine, and on the other touching Bohemia, an almost circular basin, formed by the Sudetes. These mountains, opening to the northwest, give passage to the Elbe, from Silesia.

North of the Krapack, towards the Baltic, flow the greatest rivers of Germany; among others, the Oder and Vistula. The Oder, rising in Moravia, traverses Prussia to the Baltic about 12° east longitude. The Vistula rises opposite the Theiss, wanders long on the plains of Poland, and bathes the walls of Dantzic. To the east of the Vistula, the Pruth goes towards the Danube; the Dniester and the Bong run direct to the Black sea. Thus the waters of the Carpathian mountains feed three seas.

The *Dofrine* chain is divided beyond the Baltic into three branches, from a nucleus in the middle of Scandinavia. The Dofofrial south-west traverses Sweden, and ends in front of the Danish isles :—the Langfiall, or Long mountain, goes south-east towards Norway, and ends in Cape Lindeness, at the entrance of the Cattegat;—the Kolea runs towards Lapland, and continues to North Cape, the extremity of Europe. This mass resembles a crest with unequal summits, bowed in its whole length, inclining northward, its lateral slopes presenting profound ravines, horrible precipices, and impetuous torrents falling from rock to rock. The west slope is greater than the east; and the height is inferior to the Krapack, the highest summits being 6000 feet.

The intertwisting of the secondary branches of the Dofrine, the numerous valleys, and abundant springs which burst on all sides, form many lakes;—as those of Wener, Weter, Mæter, in Sweden; Miæsen, Rands, and Fæmarand, in Norway; and in Lapland, Enara, and Tornea;—all traversed by rivers, which are channels of communication to the parts near the sea.

The granitic crust which supports the Dofrine, extends all through the north of Europe. The mass of the *Valdai* is granite, crowned by some hills, the highest about 1200 feet; distributed unequally from 30 to 36 degrees east, and from the 53d to the 57th parallel, where a branch goes north, and winding among the marshes of Finland, joins the Dofrine of Lapland, by the name of Olonetz; the northern part is always covered with snow, though not very high; and immense blocks of granite appear even on the surface of the soil. In other respects, Olonetz, like the Valdai, is composed only of primitive rocks, as different marbles, mica, quartz, labradoir, and ovoid feldspar imbedded in granite, in all the rocks, as the matrix of iron.

In approaching North Cape, says a recent traveller, a little before midnight, its rocks at first appeared to be nearly of an equal height, until they terminated in a perpendicular peak; but, on a nearer view, those within were found to be much higher than those of the extreme peak, or point. Their general appearance was highly picturesque. The sea, breaking against this immoveable rampart, which had withstood its fury from the remotest ages, bellowed, and formed a thick border of white froth. This spectacle, equally beautiful and terrific, was illumined by the MIDNIGHT SUN; and the shade which covered the western side of the rocks rendered their aspect still more tremendous.

Ascending the Icy Alps.

Giant's Needle, in the Alps.

On landing, the party discovered a grotto, formed of rocks, the surface of which had been washed smooth by the waves, and having within a spring of fresh water. The only accessible spot in the vicinity was a hill, some hundred paces in circumference, surrounded by enormous crags. From the summit of this hill, turning towards the sea, they perceived to the right a prodigious mountain, attached to the Cape, and rearing its sterile mass to the skies. To the left, a neck of land, covered with less elevated rocks, against which the surges dashed with violence, closed the bay, and admitted but a limited view of the ocean.

At midnight the sun still remained several degrees above the horizon, and continued to ascend higher and higher till noon, when, having again descended, it passed the north, without dipping below the horizon. This phenomenon, which is as extraordinary to the inhabitants of the torrid and temperate zones, as snow is to the inhabitants of the torrid zone, could not be viewed without particular interest. Two months of continued day-light, during which space the sun never sets, seem to place the traveller in a new state of existence; while the effect on the inhabitants of these regions is singular. During the time the sun is perpetually above the horizon, they rise at ten in the morning, dine at five or six in the evening, and go to bed at one. But, during the winter season, when, from the beginning of December until the end of January, the sun never rises, they sleep above half of the twenty-four hours, and employ the other half in sitting over the fire, all business being impracticable, and a constant darkness prevailing.

The mountains of Kamtschatka, and of north-eastern Asia, are conceived to be a prolongation of the western chain of America. Under the titles of the Slanovay, Yablonay, and Altai mountains, they extend in a long south-western line through Asia, till, in approaching the sea of Aral, they meet another chain from the south-east, which, under the names of Himalaya and Hindoo Coosh, have been supposed to include the loftiest summits on the globe. These chains, in traversing Persia, become much lower, but throw up considerable masses in Armenia, Asia Minor, and the frontier of Syria. These two great high lands form Asia, like America, into three low lands, of which the first, between Himalaya and the Indian ocean, consists of the maritime provinces of Persia, of Hindostan, and India beyond the Ganges; the second, between the Himalaya and Altai mountains, includes Bukharia, the great desart of Shamo and Cobi, and the greater part of China; the third, stretching from the

Altai to the Northern ocean, is composed of the wild plains of Siberia.

Like a boundary wall to the waters of the Caspian and Black Seas, *Caucasus* extends between them and consolidates the separating isthmus. This mass resembles the Pyrennees, in tracing a line a little inclined from one to the other sea, in almost corresponding latitude, of equal base, height of summits, and size of glaciers, with the same wild beauties, and mode of composition. The gates of the Caspian are as famous as Roland's breach; and the granite of Caucasus, like that of the Pyrennees, has immense coatings of slate and limestone, highly elevated; and recent observations announce metallic treasures. On the lateral slopes are marbles, selenite, alum, sulphate of iron, sulphureous and thermal waters, bitumen exuding from the rocks, and finally, at their base, are sandy tracts impregnated with salt.

Caucassus has numerous springs, though its rivers Araxes, Kur, and Kuban, are merely large brooks. The northern slope is sandy, joining the *steppes* of the Don and Volga. On the south side are Mingrelia, and Georgia, a hilly country, where are again found the situations and climate of the Tauride. The southern prolongation of the Georgian mountains (the anti-Caucassus of Strabo) joins those of Armenia, from which, Ararat, with its double summit, seems entirely detached.

Mount *Taurus*, with summits covered with snow, distinct from Ararat and Caucasus, forms, at first, a chain south-west across Asia Minor, to Cape Maeri, fronting Rhodes. This chain, corresponds with Mount Hennis faced opposite, ramifies similarly towards the north, and forms the Capes of the Black Sea, the walls of Bosphori, and rocks of the Archipelago. The northern slope, by Taurus sheltered from solar inclemency, has the climate and aspect of Greece. To the south, Taurus surmounts the plains of Chaldea, where flow the Euphrates, and Tigris, running parallel, often approaching and receding, till they unite and fall, by three mouths, into the Persian gulf, a continuation of the basin of the Euphrates. The plains of Bassora are marshy, like the lagunes of Venice; the heat is greater, soil loose, and shores more cultivated than the coast of Dalmatia.

Persia is an elevated and sandy plain, formed by four chains of contiguous mountains, forming a very irregular parallelogram; occupied eastward by the Ariapalus, a lake 140 square leagues in surface. The Paropamisus, which support it northward, and run eastward, border the southern shores of the Caspian, and are granitic; naphtha and petroleum exude in great abundance; and turquois and mines of copper are found here.

The mountains of Kurdistan join here by those of Chilam and Aiagha-Tag, branches of the anti-Caucassus. The latter separates the two vast lakes Wan and Ourmia, without any issue. South of these lakes, the Elwend mountains run parallel with the Tigris to the Persian Gulf, at only 45 leagues distant, then named Louristan, with the western slope, a salt desart, to the Tigris, and traversed by the Aluvas (Gindus of Herodotus), and some smaller streams, which flow either into the Tigris or Persian Gulf. The *thousand mountains*, Hebzer Darra, south of Persia, run nearly parallel to the Paropamisus, and command a vast plain between the Persian Gulf and mouth of the Indus; occupied by the desart of Kernan, and salt lakes, one of which receives the (Araxes, or) Bundamir.

The fourth chain, Imaus or Belour, more elevated than the others, descends from the high plains of Thibet, and joins the Hebzer Darra, by the Solyman mountains, which belong to Persia. The northern portion of Imaus traverses Independent Tartary, forming the great western slope of Asia, a series of sandy plains, with issueless lakes, above each other, terminating on the eastern bank of the Caspian; but differing in their extent; though the Aral is 1280 square leagues, and they are mostly surrounded by salt sands. The Imaus, which commands them, is always covered with snow; hence Independent Tartary is not only temperate, but even cold; and the eastern slope ends in the valley of the Indus, a fine river from the mountains of Thibet.

The mountains of Thibet, whose highest summit is Bogdo, form the great mass of Asia; whose central countries consist of a very elevated plane, of nearly the same plane between the 30th and 50th parallels, and extending from the Imaus west to China east. There are vast desarts, as Cobi, and Shumo, whose extent are not yet determined, and wherein great rivers are lost; or form issueless lakes, as the Terkiri, Kircher-Nor, &c.

Above this plane rise two chains of mountains, of very high elevation. The first, those of Thibet, border the south of the plane semicircularly. The convex part outward extends from the Imaus to the western mountains of China; and commands all India, Indo-China, and China itself. From this semicircular range, chains diverge, and form large valleys, wherein run rivers proportioned to the mass whence they rise.

Westward, on the confines of Persia, and Independent Tartary, proceeds a branch, nigh the commencement of the Imaus, with which it forms an angle, and transforms the valley of the Indus into a vast bason. This river, whose source is not precisely known, at 60 leagues from the sea, divides and forms a delta, with 50 leagues of coast, and 48 of breadth, resembling that of Egypt. The soil is light, rain unfrequent, innundations periodical, and lateral sides sandy; and on the west is a vast desart supposed to have oases, and joining those of the south of Persia.

The second, named *Himmalaya* mountains, backed against the range, runs south-east, and continuing by the Garow and the Anonpeontonniron, ends at Cape Negrais in the gulf of Bengal.

Far as they predominate over, and precipitously as they rear themselves above the rest, all the hills that appear in distant ranges, when viewed from the plains, are indeed only links of this great chain. Their horizontal depth, on that side which overlooks Hindostan, is various; but the best observations and survey do not authorise the allowance of more than an average depth of about sixty miles from the plains to their commencement. The breadth of the snowy zone itself probably varies still more; and cannot fairly be estimated at less than from seventy to eighty miles.

Captain Webb, of the Bengal establishment, was lately employed on a survey of the province of Kumaoon. On the 21st of June, his camp was 11,680 feet above Calcutta. The surface was covered with very rich vegetation, as high as the knee: extensive beds of strawberries in full flower; plenty of currant-bushes in blossom all around, in a clear spot of rich black mould soil, surrounded by a noble forest of pine, oak, and rhododendra. On the 22d he reached the top of Pilgoenta-Churhaee, 12,642 feet above

Source of the Jumna and Ganges.

Calcutta. There was not the smallest patch of snow near him, and the surface a fat black mould, through which the rock peeped, was covered with strawberry plants (not yet in flower), buttercups, dandelion, and a profusion of other flowers. The shoulders of the hill, about 450 feet above him, were covered with the same to the top; and about 500 feet below was a forest of pine, rhododendron, and birch. On the 16th July he slept at Bheemkendar, near the source of the Coonoo and Bheem streams. There is no wood near; but there was a profusion of flowers, ferns, thistles, &c. and luxuriant pasturage. Captain Webb presumes the site of Bheemkendar to be 13,000 to 13,300 feet above the level of Calcutta. From thence he ascended at first very gradually, and then very rapidly, till he left all luxuriant vegetation, and entered the region of striped, scattered, and partially melting snow, 1500 feet above Bheemkenda, or from 14,500 to 15,000 feet above Calcutta. He proceeded onwards, ascending very rapidly, while vegetation decreased gradually to a mere green moss, with here and there a few snow-flowers, till he entered the perennial and unmelting snow, entirely beyond the line of vegetation, where the rock was bare even of lichens. Having reached the top of an ascent, they looked down upon a very deep and dark glen, called Palia Gadh, the outlet to the waters of one of the most terrific and gloomy valleys ever seen. It looks like the ruins of nature, and appears completely impracticable and impenetrable. Little can be seen except dark rock: wood fringes only the lower parts and the waters' edge: perhaps the spots and streaks of snow, contrasting with the general blackness of the scene, heighten the appearance of general desolation. No living thing is seen; no motion but that of the waters; no sound but their roar. Such a spot is suited to engender superstition, and here it is accordingly found in full growth. The opposite side is particularly precipitous; yet along its face a road is carried, frequented as much as this, and leads to villages farther up. By the time they had reached the village, the clouds which had lowered around and sunk down on the hills, began to burst with loud thunder and heavy rain. The noise was fearfully reverberated among the hills; and during the night the sound was heard of fragments from the brows of the mountains, crashing down to the depths below with a terrible noise.

This branch, with the preceding, by the mountains of the Gauts prolonged to Cape Comorin, forms the bason of the Ganges; which river rises on the plain of Thibet, in 35° 45′ latitude, and 96° east longitude, meanders during 200 leagues in the high valleys of the plains; traverses the Himmalaya mountains, forming cataracts; enters the Hindostan in latitude 30°; and dividing 75 leagues from the sea, surrounds a plain in surface at least double the delta of the Nile. This great river has among its feeders, several equal to the Rhine, and very few as small as the Thames. The tide ascends more than 50 leagues above its mouth ; the mean breadth is only a quarter of a league, but near the sea it spreads so that its waters can no longer repel the sand banks by the sea accumulated, and daily increased by fluiral deposits. The banks of the Ganges are formed of moving earth often precipitated ; consequently this river, and others of that country, have several times changed their bed. In the actual state there is always one perpendicular bank, and the other sloping, varied with the sinnosities of the stream. The Delta, or Bengal, is intersected by numerous canals, marshes, and creeks, of which several are salt, whence a considerable quantity is extracted. The waters of the Ganges rise, from near the end of April to the beginning of August. Only the two seasons of the tropics are known there, and the climate being subject to the monsoons, few countries have so many violent squalls.

The third branch from the chain of Thibet, traverse the Birman Empire, to Cape Romania, south of the peninsula of Malacca. Between this branch and the preceding, flows the Ava, which also forms a delta at its mouth. But the country it traverses is more mountainous than Hindostan, and metals are found in it. Formerly, fleets came for gold to these countries, which are very rich in precious stones.

A fourth branch, more east, forms the valley of Sians ; and a fifth, that of Camboja. This last follows the coast at some distance, and is the interior limit to Cochin China, and Tonquin. The rocks of these mountains are of primitive formation ; and horizontal beds occur only at the origin of the valleys. The sea shore is strewed with pebbles, and extends so far into the ocean, as to become unfathomable only at a great distance. All the rivers in this part, like those of India, have their periodical inundations.

The southern range of Thibet ramifies only in China. The mountains of Corea, Mongolia, and all the north of Asia, belong to the northern range, the counterpart of the other, but separated by the immense central level. The highest point of this range, is the Bogdo, about 90° east, and almost under the 45th parallel. The Changai mountains, the east branch, ramify in the Corea, Mongolia, Mantchonria, and their granitic precipices border the coast of the sea of Japan. The isles disseminated in those seas, appear by the direction of their chains to be connected with the continent; but, the volcanic productions, which cover them, and the subterraneous fires, give them a peculiar physiognomy.

The *Altai* mountains, are north of Bogdo, but are connected by intermediary chains; extending west to Imaus, joining it near Palcati, a lake 200 leagues square, where begins that western slope of the central chain, which ends in the Caspian. South of lake Palcati, always nearly on the same level, are many smaller lakes, in the valleys of Thibet, where borac is collected. The ramification of the Altai chain, unfolds itself in Upper Siberia, which immense chain of Asiatic Russia, of much interest in the study of the terrestrial globe, is separated from Europe by the great chain of the Oural mountains, which, from near the Caspian, extend to the shores of the frozen ocean, and probably to Nova Zembla. Some of the summits are 6000 feet, and, to the south, ever covered with snow.

The Oural chain, of granitic and quartzose rocks, extends more west than east, replaced by schists and secondary hills. North of the Caspian and Aral, the Ouralian chain ramifies eastward and joins the Altai. This intermediate chain, the Asquidinio or Algeydanzano, is merely a series of calcareous hills, between which run several rivers.

The *Nertschinsk* chain traverses Siberia; rising east of lake Baikal, and continuing north-east by the mountains of Daouria and Okhotsk, on one side ramifying to Behring's Straits, and on the other, to Kamschatka, the Kurile isles, &c. where are ignivomous mountains, and extinct craters; as likewise in the Daurian chain, famed for metallic riches, gold, silver, and lead; and *chromium*, sometimes as a red acid, and, at others, as a green oxyd.

The mountains of Siberia, east, are granite, covered by thick schists, cut by masses of varied porphyry and jasper. In Daouria, Odon-Tchelon contains emeralds and topazes, irregularly disseminated in veins; several other precious stones also are found; and with the gold mines, form a remarkable peculiarity in these icy countries.

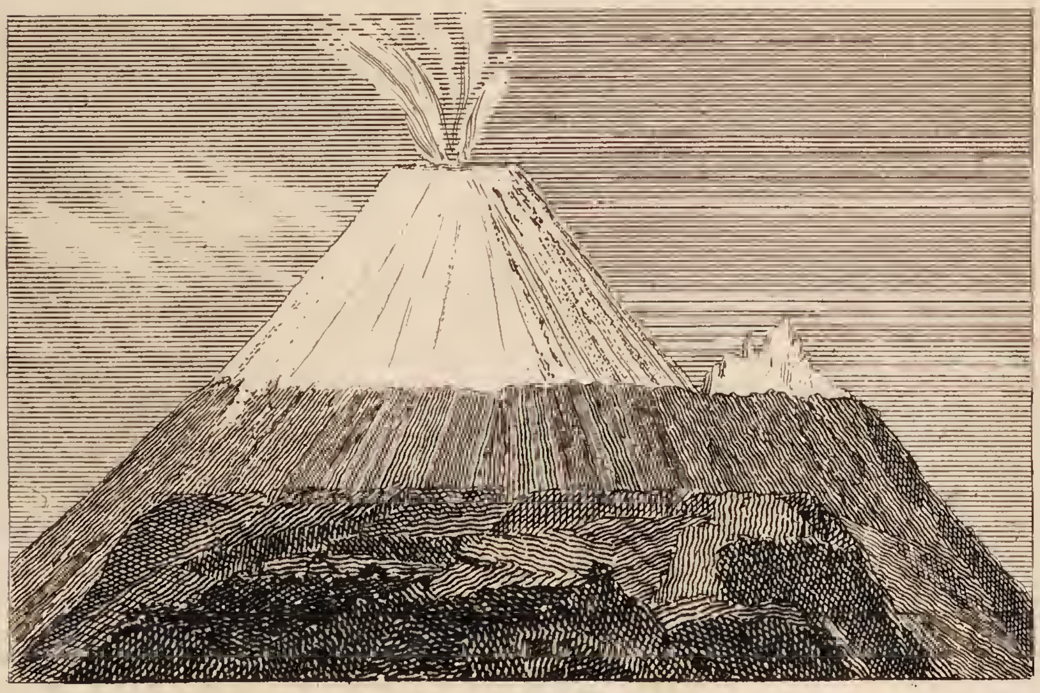
The most remarkable range of high land that occurs on the globe is that which extends along the whole western coast of America, parallel to, and at a short distance from the Pacific Ocean. This chain seems quite unbroken from Cape Horn to Mount St. Elias, and even as far as Beering's Straits. In its whole course through Peru this chain is well known to be of the most gigantic elevation; and, from the reports of travellers, it would appear, that the Andes of Chili scarcely yield to these in magnitude. At the isthmus of Panama the chain is at its lowest point, not exceeding 600 or 700 feet; but in Mexico it again rises into volcanic peaks, that almost rival Chimborazo. The Rocky mountains of North America are on a much lower scale, and do not exceed 5000 or 6000 feet; but towards the north-western extremity, Mount St. Elias again towers to a height second only to that of the loftiest Andes. Another chain on the opposite side of this continent runs parallel to the Atlantic. West of the United States it is called the Allegany and Appalachian mountains. It probably forms the high land of the West India islands, and in South America runs along the back settlements of Brazil. These two great lines of high land divide America into three low lands, two of which are between the mountain chains and the oceans, and are narrow, particularly that which borders the Pacific; the other, forming the interior, both of North and South America, is extensive, fertile, and watered by the noblest rivers in the world.

THE ANDES.

The most remarkable mountains of the Andes are those of Cotopaxi, Chimborazo, and Pichincha.

On the top of the latter was my station, says Ulloa, for measuring a degree of the meridian; where I suffered particular hardships from the intenseness of the cold, and the violence of the storms. The sky around us in general involved in thick fogs, which, when they cleared away, and the clouds, by their gravity, moved nearer to the surface of the earth, appeared surrounding the foot of the mountain, at a vast distance below, like a sea, encompassing an island in the midst of it. When this happened, the horrid noises of tempests were heard from beneath, then discharging themselves on Quito and the neighbouring country. I saw the lightning issue from the clouds, and heard the thunders roll far beneath me. All this time, while the tempest was raging be-

CHIMBORAZO the loftiest Peak of the ANDES.



The Volcano of COTOPAXI in the ANDES.

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low, the mountain top, where I was placed, enjoyed a delightful serenity. The wind was abated, the sky clear, and the enlivening rays of the sun moderated the severity of the cold. However, this was of no very long duration; for the wind returned with all its violence, and with such velocity as to dazzle the sight; while my fears were increased by the dreadful concussions of the precipice, and the fall of enormous rocks; the only sounds that were heard in this frightful situation.

The group of Chimborazo and Carguairazo, says Humboldt, has an absolute elevation of 3000 yards. We distinguish, says he, three kinds of principal forms belonging to the high tops of the Andes. The volcanoes which are yet burning,—those which have but a single crater of extraordinary size, are conic mountains, with summits truncated in a greater or less degree: such is the figure of Cotopaxi, of Popocatepec, and the Peak of Orizaba. Volcanoes, the summits of which have sunk after a long series of eruptions, exhibit ridges bristled with points, needles leaning in different directions, and broken rocks falling into ruins. Such is the form of the Altar, or Capac-Urcu, a mountain once more lofty than Chimborazo, and the destruction of which is considered as a memorable period in the natural history of the New Continent; such is the form also of Carguairaizo, a great part of which fell in on the night of the 19th of July, 1698. Torrents of water and mud then issued from the opened sides of the mountain, and laid waste the neighbouring country. This dreadful catastrophe was accompanied by an earthquake, which, in the adjacent towns of Hambato, and Llactacunga, swallowed up thousands of inhabitants.

A third form of the high tops of the Andes, and the most majestic of the whole, is that of Chimborazo, the summit of which is circular; it reminds us of those paps without craters, which the elastic force of the vapours swells up in regions where the hollow crust of the globe is mined by subterraneous fires. The aspect of mountains of granite has little analogy with that of Chimborazo. The granitic summits are flattened hemispheres, the trappean porphyry forms slender cupolas. Thus on the shore of the South Sea, after the long rains of winter, when the transparency of the air has suddenly increased, we see Chimborazo appear like a cloud at the horizon; it detaches itself from the neighbouring summits, and towers over the whole chain of the Andes, like that majestic dome, produced by the genius of Michael Angelo, over the antique monuments, which surround the Roman Capitol.

Travellers who have approached the summits of Mont Blanc and Mont Rose are alone capable of feeling the character of this calm, majestic, and solemn scenery. The bulk of Chimborazo is so enormous, that the part which the eye embraces at once near the limit of the eternal snows is seven thousand metres in breadth. The extreme rarity of the strata of air, across which we see the tops of the Andes, contributes greatly to the splendour of the snow, and the magical effect of its reflection. Under the tropics, at a height of six thousand yards, the azure vault of the sky appears of an indigo tint. The outlines of the mountain detach themselves from the sky in this pure and transparent atmosphere, while the inferior strata of the air, reposing on a plain destitute of vegetation, which reflects the radiant heat, are vaporous, and appear to veil the middle ground of the landscape.

The elevated plain of Tapia, which extends to the east as far as the foot of the altar, and of Condorasto, is three thousand metres in height, nearly equal to that of Canigou, one of the highest summits of the Pyrennees. A few plants of schinus, molle, cactus, agave, and molina, are scattered over the barren plain; and we see in the fore-ground lamas (camelus lacma) sketched from nature, and groups of Indians going to the market of Lican. The flank of the mountain presents the gradation of vegetable life, and may be followed on the western top of the Andes from the impenetrable groves of majestic palm trees, to the perpetual snows, bordered by thin layers of lichens.

At three thousand seven hundred yards absolute height, the ligneous plants with coriaceous and shining leaves nearly disappear. The region of shrubs is separated from that of the grasses by alpine plants, by tufts of nerteria, valerian, saxifrage, and lobelia, and by small cruciferous plants. The grasses form a very broad belt, covered at intervals with snow, which remains but a few days. This belt, called in the country the *pajonal*, appears at a distance, like a gilded yellow carpet. Its colour forms an agreeable contrast with that of the scattered masses of snow; and is owing to the stalks and leaves of the grasses burnt by the rays of the sun in the seasons of great draught. Above the *pajonal* lies the region of cryptogamus plants, which here and there cover the porphyritic rocks destitute of vegetable earth. Farther on, at the limit of the perpetual ice, is the termination of organic life.—*See the Engraving.*

In Lapland, the level of perpetual snow is 4000 feet; in Savoy and Switzerland it is 8000; on the Pyrennees 8100; Teneriffe is not all the year covered with snow; on the Cordelleras it is 15,747 feet, and on the north side of the Himmalayan chain, 17,000 feet. On these, at 15,000 feet are fertile pastures, where graze myriads of animals through the year.

Cotopaxi is the loftiest of those volcanoes of the Andes, which, at recent epochs, have undergone eruptions. Notwithstanding it lies near the Equator its summits are covered with perpetual

The Andes, near Quito.

Montserrat.

snows. The absolute height of Cotopaxi is 18,876 feet, or three miles and a half, consequently it is 2,622 feet, or half a mile, higher than Vesuvius would be, were that mountain placed on the top of the Peak of Teneriffe! Cotopaxi is the most mischievous of the volcanoes in the kingdom of Quito, and its explosions are the most frequent and disastrous. The masses of scoriæ, and the pieces of rock, thrown out of this volcano, cover a surface of several square leagues, and would form, were they heaped together, a prodigious mountain. In 1738, the flames of Cotopaxi rose 3000 feet, or upwards of half a mile, above the brink of the crater. In 1744, the roarings of this volcano were heard at the distance of six hundred miles. On the 4th of April, 1768, the quantity of ashes ejected at the mouth of Cotopaxi was so great, that it was dark till three in the afternoon. The explosion which took place in 1803, was preceded by the sudden melting of the snows that covered the mountain. For twenty years before, no smoke or vapour, that could be perceived, had issued from the crater; but in a single night the subterraneous fires became so active, that at sun-rise the external walls of the cone, heated to a very considerable temperature, appeared naked, and of the dark colour which is peculiar to vitrified scoriæ. "At the port of Guayaquil," observes Humboldt, "fifty-two leagues distant in a straight line from the crater, we heard, day and night, the noise of this volcano, like continued discharges of a battery; and we distinguished these tremendous sounds even on the Pacific Ocean." The form of Cotopaxi is the most beautiful and regular of the colossal summits of the high Andes. It is a perfect cone, which, covered with a perpetual layer of snow, shines with dazzling splendour at the setting of the sun, and detaches itself in the most picturesque manner from the azure vault above. This covering of snow conceals from the eye of the observer even the smallest inequalities of the soil; no point of rock, no stony mass, penetrating this coat of ice, or breaking the regularity of the figure of the cone.

At a short distance from the south bank of the St. Lawrence, run the mountains, called Apalachian, or Alleghany. Their general direction is from north to south, and terminating by several bifurcations in Tenessee, and the Floridas. The ridge consists of several parallel links, sometimes very near, with only steep and narrow valleys between them; sometimes removed, as if by concert, with ten or twelve leagues of ground intervening. Southward are some insulated peaks; but the summits are rounded, and the chain is every where of slight elevation. Otter peak, the highest, is less than 4000 feet. Their aspect differs from that of mountains in Europe; and their acclivity very abruptly terminates in even summit, with few breaks, much like a rampart with battlements.

The central link, called, on the north-east, *Alleghany Ridge*, and to the south *Blue Ridge*, continues the whole length of the chain; the base varying from 20 to 30 leagues. This central link, though less elevated than the others, parts the waters east and west.

The direction of the Alleghany chain, north and south, causes in these countries a singular effect on the climate. Advancing from the shores of the Atlantic towards the mountains, always under the same latitude, an augmentation of cold is felt, as if ascending the meridians towards the north; but having passed the chain, and descended into the great valley of the Mississipi, the heat increases, as if going towards the equator. This vicissitude continues to the sources of the Mississipi, on the plane of Upper Canada, where the icy north-west wind, stopped by that plane, does not reach the great valley. It is similar in the western part; the cold increases towards the chain of the Stony Mountains, which exerts an influence like that of the Alleghanys.

The Stony Mountains extend through North America fromthe frozen Cape to the Ishmus of Panama, always at a moderate distance from the Pacific, towards which verge several of its ramifications. Such extent must evince great varieties of composition, height, climate, steepness, &c.

The northern part, from the sources of Peace river east, and from the Columbia west, about 54° north, seems composed, like the Alleghanys, of several parallel chains, the most western going along the coast of the Pacific. The elevation is considerable, and snow is found in the high valleys in June. On the east the slope is gentle, leaning on the level of Upper Canada. The line of the junction is marked by a slip of marshy ground, bordered by mines of coal and bitumen. This slip diappears, and the slopes of the plane become obvious north and south. It is then replaced by vast plains, surrounded by hills, at the foot of the Stony Mountains, parallel therewith. The borders of the rivers which traverse these plains, are incrusted with salt, and at intervals are salt marshes and fountains. This order subsists both on the side of the Frozen Sea, where the Mackenzie river runs; and on the southern side watered by the Missouri.

COMPARATIVE HEIGHT OF PRINCIPAL MOUNTAINS.

The Stony Mountains are formed by a strange combination of primitive rocks, decomposed on several points, as in the Alleghanys. Silex predominates, and its fragments are scattered on all the slopes. This silex is perhaps only quartz arising from decomposed granite, which may also have supplied the argil or kaolin, produced by altered felspar, wherein is found incrusted that portion of the rocks which has remained unaffected; for at the source of the Peace River, the soil is a mixture of argil, sated, and small pebbles. The rocks exhibit abrupt precipices, cavities, salient masses, and other unequivocal signs of the deterioration which the air and waters necessarily occasion. A warm air and smoke exhale from some of the crevices, with a strong sulphureous smell, indicating the vicinity of volcanoes. Indeed, there are several along the western slope, on the Pacific, northward from the 60th degree.

On this coast the mountains are always covered with snow, which falls in avalanches more terrible by their enormous mass and the steepness of the descent, than those of the Alps. They follow the coast at some distance, and do not exhibit those alterations obvious in the eastern part, as the snow and fire protect the granite. North of Alayshka, the mountains have little elevation, and are composed of black granite, mica, crystallized quartz, and whetstone, with indications of iron mines, and on the side of the hills is a bed of oeraceous argil. The peninsula of Alayshka, and the Alentian Isles, (a prolongation of the chain,) have rocks of different coloured jasper; and the soil is merely a mould placed on the rock. Several of these islands are volcanic, and contain sulphur. South of the peninsula, there are several high summits, and Mount St. Elie. The mountains are separated from the sea only by a strip of marshy land, extended even to the heights; and being produced by the wearing down of the mountains, increases constantly and gains on the sea. In all this part the rivers are merely torrents, and the cold is most severe.

In Africa the Atlas at the N. W. extremity rises to a great height, but it sinks entirely before reaching the eastern coast. To the south of the Atlas extends an immense plain, composed chiefly of sandy desarts. At its termination are found two very high ranges of mountains, running inwards, one from the eastern, and the other from the western coast, and which are generally supposed to unite and form a continuous chain across the continent. There are similar ranges behind Congo and Monomopata; and the southern extremity of Africa defends itself by a high mountain wall against the force of the ocean which breaks against it. The limits, however, between mountain and plain, throughout all this part of Africa, cannot be determined with any degree of precision.

From this general view it will appear, that the principal mountain chains of America and Asia are arranged in a species of irregular arch; and it is not improbable, if we could connect the mountains of Arabia with those of Abyssinia and central Africa, that they would form a continuation of the same figure, and the whole would be found ranged around the shores of the great ocean, in a species of semicircle corresponding to that formed by the shores of the three continents. This wide circuit of high land may then be considered as the main bulwark by which the habitable globe is secured against the encroachments of the watery element.

Besides the preceding chains of mountains, there is another too remarkable to be omitted—we mean the Peak of Teneriffe, in the Canary Islands, one of the highest single mountains in the world, being about 4000 yards of perpendicular elevation. Different accounts have been published of its ascent, but the latest is by Humboldt:

Towards three in the morning, says this celebrated traveller, by the sombrous light of a few fir torches, we began our expedition for the summit of the Piton. We scaled the volcano on the north-east, where the declivities are extremely steep; and we came, after two hours toil, to a small plain, which, on account of its isolated situation, bears the name of Alta Vista. It is the station also of the Neveros, those natives, whose occupation it is to collect ice and snow, which they sell in the neighbouring towns. Their mules, better practised in climbing mountains than those hired by travellers, reach Alta Vista, and the Neveros are obliged to transport the snow to this place on their backs. Above this point the Malpays begins, a term by which is designated here, as well as in Mexico, Peru, and every other country subject to volcanoes, a ground destitute of vegetable mould, and covered with fragments of lavas.

We had yet to scale the steepest part of the mountain, the Piton, which forms the summit. The slope of this small cone, covered with volcanic ashes, and fragments of pumice stone, is so steep, that it would have been almost impossible to reach the top, had we not ascended by an old current of lava, the wrecks of which have resisted the ravages of time. These wrecks form a wall of scorious rocks, which stretches itself into the midst of the loose ashes. We ascended the Piton by grasping these half decomposed scoriæ, the sharp edges of which remained often in our hands. We employed nearly half an hour to scale a hill, the perpendicular height of which is 180 yards.

When we gained the summit of the Piton, we were surprised to find scarcely room enough to seat ourselves conveniently. We were stopped by a small circular wall of porphyritic lava, with base of pitchstone, which concealed from us the view of the crater. The west wind blew with such violence that we could scarcely stand. It was eight in the morning, and we were frozen with the cold, though the thermometer kept a little above the freezing point.

The brink of the crater of the Peak bears no resemblance to those of the greater part of the other volcanoes which I have visited: for instance, the craters of Vesuvius, Jorullo, and Pichincha. In these the Peak preserves its conic figure to the very summit: the whole of their declivity is inclined the same number of degrees, and uniformly covered with a layer of pumice stone, very minutely divided; so that when we reach the top of them, nothing obstructs the view of the bottom of the crater. The Peak of Teneriffe, and Cotopaxi, on the contrary, are of very different construction. At their summit a circular wall surrounds the crater; which wall, at a distance, has the appearance of a small cylinder placed on a truncated cone. On Cotopaxi this peculiar construction is visible to the naked eye at more than three miles distance; and no person has ever reached the crater of that volcano. On the Peak of Teneriffe, the wall which surrounds the crater like a parapet, is so high, that it would be impossible to reach the crater, if on the eastern side there was not a breach, which seems to have been the effect of a flowing of very old lava. We descended through this breach toward the bottom of the funnel, the figure of which is elliptic. Its greater axis has a direction from north-west to south-east, nearly N. 35° W. The greatest breadth of the mouth appeared to us to be 300 feet, the smallest 200 feet.

Is the conical mountain of a volcano entirely formed of a liquified matter, heaped together by successive eruptions; or does it contain in its centre a nucleus of primitive rocks covered with lavas, which are the very rocks altered by fire? What are the affinities which unite the productions of modern volcanoes with the basaltes, the phonolites, and those porphyries with bases of feldspar, which are without quartz, and which cover the Cordilleras of Peru and Mexico, as well as the small groups of the Monts d'Or, of Cantal, and of Mezen in France? Has the central nucleus of volcanoes been heated in its primitive position, and raised up in a softened state by the force of the elastic vapours, before these fluids communicated, by means of a crater, with the external air? What is the substance which, for thousands of years, keeps up this combustion, which is sometimes so slow, and at other times so active? Does this unknown cause act at an immense depth ; or does this chemical action take place in secondary rocks lying on granite ?

We reached the inside of the crater with less difficulty than we at first expected, and examined the cone from its summit to its basis; we were struck with the difference in the produce of each eruption, and with the analogy which still exists between the lavas of the same volcano: but, notwithstanding the care with which we interrogated Nature, and the number of partial observations which were presented at every step, we return from the summit of every burning volcano less satisfied than when we were preparing to go thither. It is after we have studied them on the spot, that Volcanic phænomena appears still more isolated, more variable, and more obscure, than we imagined them when consulting the narratives of travellers.

We descended to the bottom of the crater on a train of broken lava, from the eastern breach of the enclosure. The heat was perceptible only in a few crevices, which gave vent to aqueous vapours with a peculiar buzzing noise. Some of these funnels or crevices are on the outside of the enclosure, on the external brink of the parapet that surrounds the crater. We plunged the thermometer into them, and saw it rise rapidly to 68 and 75 degrees. It no doubt indicated a higher temperature, but we could not observe the instrument till we had drawn it up, lest we should burn our hands. M. Cordier found several crevices, the heat of which was that of boiling water. It might be thought that these vapours which are emitted in gusts, contain muriatic or sulphurous acid ; but, when condensed, they have no particular taste; and experiments, which several naturalists have made with reagents, prove, that the chimneys of the Peak exhale only pure water. This phænomenon, analogous to what I observed in the crater of Jorullo, deserves the more attention, as muriatic acid abounds in the greater part of volcanoes, and as M. Vauquelin has discovered it even in the porphyritic lavas of Auvergne.

We prolonged in vain our stay on the summit of the Peak, to wait the moment when we might enjoy the view of the whole of the Archipelago of the Fortunate Islands. We discovered Palma, Gomera, and the Great Canary at our feet. The mountains of Lanzerota, free from vapours at sun-rise, were soon enveloped in thick clouds. On a supposition only of an ordinary refraction, the eye takes in, in calm weather, from the summit of the volcano, a surface of the globe of 5700 square leagues, equal to a fourth of the surface of Britain. The question has often been agitated, if it were possible to perceive the coast of Africa from the top of this colossal pyramid; but the nearest parts of this coast are still farther from Teneriffe than 2° 49′, or 56 leagues. The visual ray of the horizon from the Peak being 1° 57′, Cape Bojadoz can be seen only on the supposition of its height being 400 yards above the level of the ocean.

We could not withdraw our eyes, on the summit of the Peak, from observing the brilliant colour of the azure sky. Its intensity at the zenith appeared to correspond to 41° of the cyanometer. We know by Saussure's experiment, that this intensity increases with the rarity of the air, and that the same instrument indicated at the same period 20° at the priory of Camouni, and 40° at the top of Mont Blanc. This last mountain is 540 yards higher than the volcano of Teneriffe; and if, notwithstanding this difference, the sky is seen there of a less deep blue, we must attribute this phænomenon to the dryness of the African air, and the proximity of the torrid zone.

Notwithstanding the heat we felt in our feet on the edge of the crater, the cone of ashes remains covered with snow during several months in the winter. It is probable, that under the cap of snow considerable hollows are found, like those we find under the glaciers of Switzerland, the temperature of which is constantly less elevated than that of the soil on which they repose. The cold and violent wind which blew from the time of sun-rise, forced us to seek shelter at the foot of the Piton. Our hands and faces were frozen, while our boots were burnt by the soil on which we walked. We descended in the space of a few minutes the Sugar Loaf which we had scaled with so much toil; and this rapidity was in part involuntary, for we often rolled down on the ashes. In spite of our toils it was not without regret that we quitted this solitary place, this domain where Nature towers in all her solemn majesty.

The mountains true sublime in ether rise,
Transfix the clouds, and tower amid the skies;
The snowy fleeces, which their heads involve,
Still stay in part, and still in part dissolve;
Torrents and loud impetuous cataracts
Through roads abrupt, and rude unfashioned tracts
Roll down the lofty mountain's channelled sides,
And to the vale convey their foaming tides;
At length, to make their various currents one,
The congregated floods together run;
These confluent streams make some great river's head,
By stores still melting and descending fed.

LECTURE XXVIII.

ON MINERAL PRODUCTIONS AND MINES.

Through dark retreats pursue the winding ore;
Search Nature's depths, and view her boundless store;
The secret cause in tuneful numbers sing,
How metals first were framed, and whence they spring:
Whether the active sun, with chemic flames,
Through porous earth transmits his genial beams;
With heat impregnating the womb of night,
The offspring shines with its paternal light:—
Or, whether, urged by subterraneous flames,
The earth ferments, and flows in liquid streams;
Purged from their dross, the nobler parts refine,
Receive new forms, and with fresh beauties shine:—
Or, whether by creation first they sprung,
When yet unpoised the world's great fabric hung:
Metals the basis of the earth were made,
The bars on which its fix'd foundation's laid:
All second causes they disdain to own,
And from th' Almighty's fiat sprung alone. YALDEN.

In the adjoining lectures we have treated of the disposition of the different kinds of earths, the changes which the surface of the earth has undergone at different periods, its wonderful natural fissures and caverns, and of the nature and origin of that part of fossil productions, which are denominated *extraneous.* We shall here proceed to give a succinct view of the earth's several mineral productions, with a view to illustrate this important branch of the economy of nature.

On taking a cursory view of the surface of this globe, composed of high, wild, and rocky mountains, its numerous valleys, rivers, and undulated surface, together with the vast expanse of ocean, we are apt to consider the mountains and rocks as forming a kind of chaos, without regularity or order; but the laborious and patient investigations of mineralogists have shown, that there is in the arrangement of the various rocks, an order and regularity beyond what was, or is, commonly imagined,—a regularity perfectly consistent with that Infinite wisdom and Almighty power which formed the vast, the unbounded system of the universe. It is this regularity in the succession and arrangement of the various rocks, from the Alpine heights to the valleys and level of the sea, which guides the mineralogist in his investigations, when searching for those minerals which are so beneficial to man in the state of civilized society.

Veins of metal are found in rocks, aggregated, in masses, more broad than thick, and differing essentially from the rocks they traverse; but often continuing several leagues in varied directions. In mining countries, the mountains are variously pierced by veins, shelving from the horizontal position to a vertical, and even crossing each other on different points. Sometimes a vein appears again at some distance, after being interrupted by something from ulterior and local changes experienced by the granitic formation; or from inability of the veins, at the formation of the mountains, to follow the rise of that formation. Veins were horizontal at their commencement, and in the granitic mass, as it lay round the nucleus, formed ramifications on all points. But on the rising of the granite, veins started up, or were broken, according to the projection of the spot on which they lay.

Veins vary in thickness, or magnitude, from one inch to several yards. The largest are not the richest; and the part nearest the soil is often thicker than the lower extremity. Veins of metal seldom occur in real granite, but in gneiss and schist.

The matter of a vein is composed of some sort of *ore,* in a kind of matrix, surrounded by borders. The latter are earthy substances, different from the rock, which serves as a wall or roof when the vein is horizontal or inclined; or as a partition when it is vertical. Argil, quartz, and calcareous spar, form mostly the borders; and, though distinct, part of the matrix. Yet the parts of the vein do not separate neatly; but often there is a mixture of the ore, matrix, and border, and even of the rock also. The parcels of ore, are, in some places, disseminated in the mass of the mountains; hence mines which have been worked and abandoned, may, after a certain time, become again productive.

And now the regions deep explore,
Where metals ripen in vast cakes of ore.
Here, sullen to the sight, at large is spread
The dull unwieldy mass of lumpish lead.
There, glimm'ring in their dawning beds, are seen
The light aspiring seeds of sprightly tin.
The copper sparkles next in ruddy streaks.

The silver then, with bright and burnish'd grace,
Youth and a blooming lustre in its face,
To th' arms of those more yielding metals flies,
And in the folds of their embraces lies. GARTH.

The ore, or metallic matter, as found, has five varied forms or states, *native, mixed, oxidised, combustible, acidiferous.* Gold, silver, mercury, copper, bismuth, antimony, and arsenic, are found in their native state. Mercury is not originally native, but it becomes so by the least heat, and flows into the hollows of rocks, where it is gathered. Of native metals, only gold, silver, and copper, are found in primitive rocks. Quartz is the matrix of gold, calcareous spar of silver, and argil of copper. Veins of copper are scarce; it is mostly in layers; but the two other are never so. Silver veins are the richest; gold, less so, most gold being gathered in the sand of rivers, or extracted from earth by washing. *Mixed* mines are common. Gold is found with tellurium; silver with mercury; antimony with arsenic; arsenic with iron, &c. &c. Often several metals appear together, as in mines of gold, silver, lead, mercury, &c. or intimately combined in globules, as platina, which may be connected with 8 or 10 different metals.

Except platina, gold, and silver, the other metals are all found in the state of oxide. Manganese and iron abound, and continually appear in other formations, because of their great oxydation. Iron mines are so numerous as to be classed into *oxidulated, pyrocete, oligist,* and *oxidated* iron. The first comprehends all mines whose iron has very little oxygen, and affects the magnetic needle. To this belongs the loadstone; found in the superior part of the mine. This iron occurs only in primitive rocks, in large deep beds. The pyrocete iron, more oxidised, arises from volatilization by volcanos. Oligist iron is yet more oxidised, and does not affect the magnet; to this belong all specular irons, commonly found in primitive rocks, always in layers. Oxidated iron, which has lost its metallic character, and is reduced to the earthy state, is confounded and mixed with the earths in the hematites, and other inferior ores of iron.

Such are Nature's means of assimilating the metals in the divers phenomena of the globe. By varied oxidadations they assimilate to the rocks, are confounded with the earths, and diffused every where. All the metals, combined with oxygen, exhibit similar results to iron. Carbon, phosphorus, sulphur, and perhaps similar combustibles yet unascertained, acting as mineralizers, reduce the metals into carburets, phosphurets, sulphurets, &c.

The most common and richest mines are sulphuretted; as those of arsenic known by the name of *orpiment* and *realgar*; of grey antimony blende, or sulphuretted zinc, nickel, sulphuret of bismuth, galena, cinnabar, martial pyrites, &c. The least humidity decomposes the sulphuret of iron; the metal then passes to oxide, and the sulphur to acid; whence the ores of slimy iron, and the various sulphates. This decomposition is also the origin of the sulphureous waters; the pyrites in decomposing, burn, and the heat is absorbed by any water near, which becomes proportionally heated.

The acids also act powerfully. When they meet oxidised metals they combine and form metallic salts. Except gold and platina, all metals are thus transformed by the sulphuric, muriatic, carbonic, and phosphoric acids. The acidifiable metals also combine often with the various oxides, and form saline mineral compounds, as chromate of iron, molybdate of lead, arseniate of cobalt, &c. These are common; (but not in primitive formations;) and are proved to be formed posterior to the granite; as all the mines of the primitive mass which afford such saline compounds, give them at the head of the veins, and of but few yards in depth. All metallic sulphates are from decomposed sulphurets: iron seems the only metal whose salts are in deep beds, yet always in the secondary rocks.

GRANITE contains fewer and less extensive metalliferous veins and beds than the slaty rocks of the primitive class. Tin, of all the metals, is that which is most peculiar to granite. Tin-stone occurs in the granite of Cornwall, Saxony, Limoges, and in these countries is generally associated with wolfram. Iron is frequent in granite. The mines of Traverella, in Piedmont, are situated in a granite which is subordinate to mica-slate. The mines of brown iron ore at Taurynià, and of Fillolo in the eastern Pyrenees, are in granite. Iron pyrites is frequently found disseminated through granite: and galena, or lead-glance, graphite, molybdena, bismuth, gold, silver, copper, zinc, manganese, cobalt, are among the metals sometimes met with in this rock.

GNEISS is one of the most metalliferous of the primitive rocks. The metals occur in veins, beds, and imbedded masses, but in greatest variety in veins. There are few metals that do not occur in it. Most of the Saxon, Bohemian, and Saltzburg mines are situated in this rock. The oldest formation appears to be that which contains tinstone. The tin-ore is accompanied with arsenic-pyrites, fluor spar, chlorite, topaz, and opal. The second formation appears to be lead-glance. The third formation consists principally of copper, and the ores are grey copper-ore, copper-glance, copper-pyrites, and variegated copper-ore. The fourth formation, which is very extensive, contains ores of cobalt. The newest formation is that which contains ores of silver. Veins, containing antimony and red ironstone, occur in gneiss, and these are supposed to be newer than any of the preceding. Veins of quartz with gold also occur in gneiss. The metalliferous beds that occur in this rock contain magnetic iron-ore, argentiferous lead-glance, blende, copper, and iron-pyrites. The lead-mines of Strontian are situated in gneiss.

Mica Slate is another of the most metalliferous of the mountain rocks. The ores it contains occur frequently in beds, but more rarely in veins, which is directly the reverse of gneiss, where ores occur more frequently in veins than in beds. The ores that occur in beds are the following: magnetic ironstone, iron-pyrites, copper-pyrites, arsenic-pyrites, red-iron ore, lead-glance, blende, gold, and glance-cobalt; and these ores are accompanied with actynolite, garnet, and asbestus.

Clay-slate is rich in metals. It contains many of the venigenous formations that occur in the preceding primitive rocks, as tin, lead, cobalt, and silver. Very considerable metalliferous beds also frequently occur, and these contain copper-pyrites, red copper-ore, copper-green, blue copper, malachite, iron-pyrites, magnetic-pyrites, glance-cobalt, grey cobalt-ore, arsenic-pyrites, blende, and lead-glance. Gold occurs in this formation, and also cinnabar.

The metalliferous beds in primitive limestone, contain ores of different kinds, as lead-glance, blende, magnetic ironstone, magnetic-pyrites, auriferous arsenic-pyrites, and native gold.

Serpentine contains magnetic ironstone, either in imbedded grains and masses, or in small veins, and these are sometimes so considerable as to be worthy of being worked as mines.

The richest mines at present known, those of Mexico, are situated in enormous veins that traverse sienitic porphyry. The mines of Hungary, the most considerable on the continent of Europe, are situated in the same kind of porphyry; and it would appear that the famous mines of Cyprus, so much extolled by the ancients, were also in porphyry. The numerous veins of lead, copper, and silver, worked at Giromagny, in the Vosges, are in a porphyry tract.

Quartz rock often contains disseminated iron pyrites, and occasionally lead-glance, copper-pyrites, and blende.

Ores, of various descriptions, abound in gray wacke and transition clay-slate; thus the lead mines of Leadhills, and of Wanlockhead, are situated in these rocks, and the same is the case with the productive lead and silver mines in Hanover, in Transylvania, in France, and in Mexico.

The ores most frequently met with in the last formation, are clay, iron-ore, and galena, or lead-glance. The iron-ore occurs every where in the coal-fields of this island; but the lead-glance is found in quantity only in the coal-districts in the north of England and in Wales. Copper, silver, and even gold, are among the metalliferous productions of this formation.

The lead mines of Northumberland and Durham, and the lead and copper mines of Derbyshire, are situated in mountain limestone.

It appears that metals differ in the period of their formation, according to the age of the rocks. That the variety and quantity of metalliferous substances decrease in general from the primitive to the alluvial period of the earth's formation. That cerium, chrome, and bismuth, are metals of the oldest primitive formation. That arsenic, cobalt, nickel, silver, and copper, extend to newer mountains. That gold, tellurium, antimony, and manganese, are metals of a middle age, occurring in the newer primitive, the transition, and the oldest secondary-rocks. That lead, zinc, and mercury, are of later date, when compared with those metals occurring in greatest quantity in the newer or secondary formations. That iron is found in every rock, from the oldest granite to the newest alluvial deposit, and is therefore a production of every period.

In Cornwall, the common opinion entertained by the miners is, that crude immature minerals nourish and feed the ores with which they are intermixed in the mines; and that the minerals themselves will, in process of time, be converted into ores productive of those metals to which they have the nearest affinity, and with which they have the greatest intercourse.

The richest and most celebrated gold and silver-mines are those of Peru and Chili, in South America. Iron-mines are more abundant in Europe than elsewhere. Copper-mines are chiefly found in Sweden, Denmark, and England; and lead and tin-mines in England; the latter, more particularly in the county of Cornwall. Quicksilver-mines abound principally in Hungary, Spain, Friuli in the Venetian territories, and Peru; diamond-mines in the East Indies and Brazil, and salt-mines in Poland.

The mountain of Potosi produces weekly about five thousand marks of silver, that is from thirty to forty thousand dollars. Six thousand Indians, or Negroes, are sent every eighteen months, to work these mines.

The mines of Mexico, or New Spain, have been more celebrated for their riches than those of Potosi, notwithstanding which the ores are remarkable for the poverty of the mineral they contain. A quintal, or one thousand six hundred ounces of silver ore, affords, at a medium, not more than three or four ounces of pure silver, about one-third of what is yielded by the same quantity of ore in Saxony. It is not, therefore, owing to the richness of the ore, but to its abundance, and the facility of working it, that the mines of New Spain are so much superior to those of Europe.

The mines of Guanaxuato, infinitely richer than those of Potosi ever were, afforded from 1796 to 1803, nearly forty millions of dollars in gold and silver, or very nearly five millions of dollars annually, being somewhat less than one-fourth of the whole quantity of gold and silver from New Spain.

From 1492 to 1803, the quantity of gold and silver extracted from the American mines has been equal in value to 5,706,700,000 dollars; of which immense sum, the portion brought into Europe, including the booty made by the conquerors of America, is estimated at 5,445,000,000, giving an average of 17 millions and a half of dollars yearly. The annual importation being divided into six periods, appears to have been constantly augmenting, and in the following progressive ratio. From 1492 to 1500, it did not exceed 250,000 dollars. From 1500 to 1545, it amounted to three millions of dollars. From 1545 to 1600, to 11 millions. From 1600 to 1700, to 16 millions. From 1700 to 1750, to 22 millions and a half. And, lastly, from 1750 to 1803, to the prodigious sum of 35,300,000 dollars, nearly equal to eight millions sterling. Humboldt calculates the weight of silver in three centuries, at 316 millions of lbs.

The gold mines of Brazil are very productive. Those called *General* are distant about seventy-five leagues from Rio Janeiro, which is the staple and principal outlet of the riches of the Brazilian territory. They yield to the state, annually, for its right of fifths, at least one hundred and twelve arrobas (weighing twenty-five pounds each) of gold. Their yearly produce, may, therefore, be estimated at upwards of eight hundred thousand pounds sterling; and that of the more distant mines at about one-third the sum.

Mozambique in Africa, abounds in gold, which is washed down by the rivers, and forms a chief part of the commerce of the country. The kingdoms of Monomotapa and Sofala likewise furnish considerable quantities of gold; and the Portuguese report that they yield annually more than a million sterling.

The most productive gold mines in Asia are those in the Island of Japan. The gold is procured by washing the sands, and a small quantity is likewise found in the ore of copper. The richest gold ore, and that which yields the finest gold, is dug in one of the northern provinces of the island of Niphon, a dependency of Japan, where gold mines were formerly very productive.

Thibet contains a great abundance of gold, which is traced in the rivers flowing from that territory into the Ganges. In Hindostan there are many mines of gold. Bosina, in Sclavonia, contains rich mines of gold and silver. The produce of the latter resembles the native silver of Potosi, and is found, combined with pure quartz, in small thin leaves resembling moss. Norway contains silver mines, which are extremely valuable. In 1751, forty-one shafts and twelve veins, were wrought in one mine, and gave employment to 3,500 officers, artificers, and labourers.

The gold and silver mines of Hungary and Transylvania, are the only ones in Europe of fixed and stable importance, and till the discovery of Peru, Mexico, and Brazil, were held of prime consideration. The well-known mines of Schemnitz and Kremnitz, with those of Kapnick, Nagy, Banya, Voros Patack, and others, are still worked to great advantage. Hungary also contains copper mines of great importance, and indeed the richest in Europe; those of Oravitza, Moldava, and others in the Banat; those of Iglo, Dobschau, Smolnitz, Herrengrund, Libethen, are in Hungary. Iron mines abound, and the mineral, from its excellent nature and quality, may be compared with that of Sweden or Norway. Some few mines of quicksilver are also found, but the quantity extracted is small.

M. Beudant, in his recent Travels in Hungary, published in the Journal of Voyages and Travels, gives the following description of the gold and salt mines of that country.

"The works at Villiczka," says he, "are on a grand scale, con ducted with perfect regularity, and even with a sort of luxury. Beau tiful galleries, large and elevated, form easy communications between all the works of each story; superb escaliers, cut in the saline mass, or constructed of solid timber-work, in the heart of the different excavations, produce a general circulation, and points of junction between the upper surface at the aperture, and the labours throughout, even where they are the deepest. In general, this depot may be considered as an immense mass of argile, called by the workmen *halda*, disposed, not in strata, but in vast bodies unusually voluminous, to which names have been given according to their respective positions, and the degree of purity in the salt. The works are divided into stories; the first, or uppermost, is a coarser sort, called *gransalz*, or greensalt. The second story exhibits a purer salt, named spiza, immense quantities of which are exported to foreign countries. The third and last story, named szibic, is lamellated, that is, divided into a number of thin plates. Organic remains have been occasionally discovered in this mine. Remnants of cray fish, and the shells called *chamites*, have been found in the heart of the saliferous argile. It is not unusual to meet with ammonites, and other marine shells, even in the salt itself, and in the argile, petrifactions, and pit-coal. M. Townson noticed little bivalve shells in the argile that encloses the spiza salt. Some have mentioned elephants' teeth, and the ossifications of quadrupeds, but these have rather been found in the lands, increased by river slime, of the adjacent plain, than in the saliferous depot. The greatest depth of the labours in the mine of Villiczka is about 960 feet below the surface. The descent into the mine is about 150 feet below the level of the sea.

The organic remains peculiar to these mines consist of lignites, or fossil carbonized wood, scattered through the salt, and marine shells enclosed in the saliferous argile. The fossil wood is so abundant in the spiza salt, that it is hardly possible to break off a piece wherein some will not appear. Some have nearly passed into a state of jet by transformation, others are altogether bituminous, and retain their figure. There are very large trunks and fragments, as well as very thin branches of trees. I have been informed that leaves, in the form of cords, have sometimes been found. I observed, in the director's collection, a fruit of a round form, of the size of a nut, in tolerable preservation.

All the depots of salt, at Villiczka and Bochnia, with all those in Gallicia and the Buckawine, as well as in Hungary, are found uniformly in one position, i. e. at the foot of a chain of mountains. The saliferous depots of Poland are always on the borders of plains, and only at the height of about 760 feet above the level of the sea, while in the depots of the Alps, that are, apparently, of more ancient formation, they are found at the height of 4850 feet above the same level. The salt-mine of Bochnia, about four leagues from that of Villiczka, exhibits similar characters, and is probably a continuation of it.

The gold mines of Cremnitz lie 40 miles south of the Carpathian hills; and 20 miles farther to the south, are the silver mines of Shemnitz. Hungary is beside enriched by a mineral peculiar to itself, or one, at least, which has not hitherto been discovered elsewhere, namely, the opal—a gem preferred to all others by the oriental nations. The opal mines are situated at Ozerwiniza, where they are found in a hill consisting of decomposed porphyry, a few fathoms beneath the surface. Their produce is of various qualities, from the opake-white, or semi-opal, to the utmost refulgence of the lively colours by which this noble gem is distinguished.

The quicksilver mines of Idria are the most interesting of these. They were discovered in 1497. The subterraneous passages of the great mine are so extensive, that it would require several hours to pass through them. The greatest perpendicular depth, computing from the entrance of the shaft, is 840 feet; but as these passages advance horizontally under a high mountain, the depth would be much greater if the measure were taken from the surface. To these pernicious caverns criminals are occasionally banished by the Austrian government.

Spain was, according to ancient writers, very rich in gold and silver; and accordingly Gibbon calls that kingdom "the Peru and Mexico of the old world." Portugal contains, beside others, rich ores of silver.

The COPPER and IRON MINES of Sweden are the most celebrated and most valuable in Europe, and are of wonderful magnitude.

Of the great *Copper Mine of Fahlun*, in Swedish Dalecarlia, Dr. Clarke gives the following description. "The mine of Fahlun is an enormous crater, shaped like a sugar-loaf, with its point downwards; the same shape having been that of the natural deposit of the pyritous copper here found. At the bottom of this crater, at the depth of 80 yards from the surface, various openings lead to the different levels and places of further descent into the mine. The view in descending the platforms is very striking; the whole being open to day-light, and

Copper Mine of Fahlen in Sweden.

the sides of the great crater being diversified, like those of Vesuvius after some of its eruptions, with a rich contrast of beautiful colours. Having entered into the opening, we found, after proceeding to a short distance from the mouth of it, some labourers who were employed in widening the passage. This was effected by means of gunpowder; and the force of the explosions, for blasting the rocks, shook every thing that was near to us. Passing into the deeper chambers, we at last arrived at the depth of 350 yards from the surface; but there are much deeper excavations; some of which have been carried on to the depth of 400 yards. Here we found the heat very oppressive*: the miners, with the exception of their drawers and shoes, were naked at their work. This high temperature increases always in the direct proportion of the descent from the surface of the earth, and is observed in all mines. In the great mine of Poldice, near Truro in Cornwall, which has been worked, in granite, to the depth of 600 yards, the miners, as at Fahlun, carry on their labours naked; and the heat is so great at the bottom of the mine, notwithstanding the accumulating water, that it may be sensibly felt by any person placing his hand against the sides of the rock, as the author himself experienced. The heat of the Fahlun mine is so great, that it becomes intolerable to a stranger who has not undergone the proper degree of seasoning which enables a miner to sustain it. But then there are causes which tend greatly to increase the natural temperature; prodigious fires are frequently kindled, and at a very considerable depth in the mine, for the purpose of softening the rocks previously to the application of gunpowder: add to this, the terrible combustion which has taken place in the mine, threatening its destruction. We saw the walls which they had constructed for opposing its progress; and the overseers, by opening some double doors placed in these walls, gave us a transient view of the fire itself, that was at this time menacing with its ravages the whole of these ancient and valuable works. The sight we had of it was short; because the fumes of sulphur were so powerful, that we found it impossible to remain many seconds within the apertures. By rushing in for an instant, we saw enough to convince us what the fate of the mine would be if the devouring element were not thus pent, and held in subjection by the smothering nature of its own exhalations. The moment any air was admitted from the doors, and the vapours were thereby partially dispersed, whole beds of pyritous matter appeared in a state of ignition; the fire itself becoming visible: but our torches were extinguished instantaneously, and it was only by holding a piece of cloth before the mouth and nostrils that we could venture beyond the second door. If this conflagration should extend to a greater depth, the mine would be destroyed by the fumes alone; as it would become impossible to proceed with the works in the midst of its exhalations. At the depth of 350 yards we were conducted into a large open chamber or cave, in which 15 naked miners were actively engaged, carrying on their labours. Here the heat was so powerful, that we found it necessary to begin our re-ascent, being very much exhausted."

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* A series of investigations respecting the temperature of mines, has for several years past been carried on in Cornwall, under the direction, principally, of Messrs. R. W. Fox and M. P. Moyle. The latter is of opinion, that the observations prove the existence of a high temperature in the interior of the earth, while Mr. Moyle refers the augmentation of temperature in the mines entirely to causes of a local and accidental nature. At 100 fathoms depth the thermometer averages from 60 to 68°: at 200 fathoms from 70 to 79°; and in Dolcoath, at 230 fathoms, $75\frac{1}{2}$°.

One of the most remarkable of the Swedish mines, if the name can with propriety be applied to it, is Tabern, a mountain of a considerable size, composed entirely of pure iron ore, and occurring in a large tract of sand over which it seems to have been deposited. This mountain has been wrought for nearly three centuries, notwithstanding which its size is scarcely diminished. The richest iron mine of Sweden is that of Danmora, in the province of Upland. It is in depth eighty fathoms, occupies a considerable extent of territory; and its ore is conveyed to the surface of the earth, through several pits or openings made for that purpose, by means of casks fixed to large cables, which are put in motion by horses.

The following account of another of these tremendous excavations in Sweden is in the second sect. of the third part of Dr. Clarke's Travels. "For grandeur of effect," says he, "filling the mind of the spectator with a degree of wonder which amounts to awe, there is no place where human labour is exhibited under circumstances more tremendously striking. As we drew near to the wide and open abyss, a vast and sudden prospect of yawning caverns and of prodigious machinery prepared us for the descent. We approached the edge of the dreadful gulf whence the ore is raised, and ventured to look down; standing on the verge of a sort of platform, constructed over it in such a manner as to command a view into the great opening as far as the eye could penetrate amidst its gloomy depths: for, to the sight, it is bottomless. Immense buckets, suspended by rattling chains, were passing up and down; and we could perceive ladders scaling all the inward precipices, on which the work-people, reduced by their distance to pigmies in size, were ascending and descending. Far below the utmost of these figures, a deep and gaping gulf, the mouth of the lowermost pits, was, by its darkness, rendered impervious to the view. From the spot where we stood, down to the place where the buckets are filled, the distance might be about 75 fathoms; and as soon as any of these buckets emerged from the gloomy cavity we have mentioned, or until they entered into it in their descent, they were visible; but below this point they were hid in darkness. The clanking of the chains, the groaning of the pumps, the hallooing of the miners, the creaking of the blocks and wheels, the trampling of horses, the beating of the hammers, and the loud and frequent subterraneous thunder from the blasting of the rocks by gunpowder, in the midst of all this scene of excavation and uproar, produced an effect which no stranger can behold unmoved. We descended with two of the miners, and our interpreter, into this abyss. The ladders, instead of being placed, like those in our Cornish mines, on a series of platforms as so many landing-places, are lashed together in one unbroken line, extending many fathoms; and being warped to suit the inclination or curvature of the sides of the precipices, they are not always perpendicular, but hang over in such a manner, that even if a person held fast by his hands, and if his feet should happen to slip, they would fly off from the rock, and leave him suspended over the gulf. Yet such ladders are the only means of access to the works below; and as the labourers are not accustomed to receive strangers, they neither use the precautions, nor offer the assistance, usually afforded in more frequented mines. In the principal tin-mines of Cornwall, the staves of the ladders are alternate bars of wood and iron: here they were of wood only, and in some parts rotten and broken, making us often wish, during our descent, that we had never undertaken an exploit so hazardous. In addition to the danger to be apprehended from the damaged state of the ladders, the staves were covered with ice or mud; and thus rendered so cold and slippery, that we could have no dependence on our benumbed fingers, if our feet failed us. Then, to complete our apprehension, as we mentioned this to the miners, they said,—'Have a care! It was just so, talking about the staves, that one of our women fell, about four years ago, as she was descending to her work.' 'Fell!' said our Swedish interpreter, rather simply; 'and pray what became of her?' '*Became of her!*' continued the foremost of our guides, disengaging one of his hands from the ladder, and slapping it forcibly against his thigh, as if to illustrate the manner of the catastrophe,—'*she became* (pankaka) *a pancake.*'

As we descended farther from the surface, large masses of ice appeared, covering the sides of precipices. Ice is raised in the buckets with the ore and rubble of the mine; it has also accumulated in such quantity in some of the lower chambers, that there are places where it is 15 fathoms thick, and no change of temperature above prevents its increase. This seems to militate against a notion now becoming prevalent, that the temperature of the air in mines increases directly as the depth from the surface, owing to the increasing temperature of the earth under the same circumstances and in the same ratio; but it is explained by the width of the aperture at the mouth of this mine, which admits a free passage of atmospheric air. In our Cornish mines, ice would not be preserved in a solid state at any considerable depth from the surface.

After much fatigue, and no small share of apprehension, we at length reached the bottom of the mine. Here we had no sooner arrived than our conductors, taking each of us by an arm, hurried us along, through regions of 'thick ribbed ice' and darkness, into a vaulted level, through which we were to pass into the principal chamber of the mine. The noise of countless hammers, all in vehement action, increased as we crept along this level; until at length, subduing every other sound, we could no longer hear each other speak, notwithstanding our utmost efforts. At this moment we were ushered into a prodigious cavern, whence the sounds proceeded; and here, amidst falling waters, tumbling rocks, steam, ice, and gunpowder, about 50 miners were in the very height of their employment. The magnitude of the cavern, over all parts of which their labours were going on, was alone sufficient to prove that the iron ore is not deposited in veins, but in beds. Above, below, on every side, and in every nook of this fearful dungeon, glimmering tapers disclosed the grim and anxious countenances of the miners. They were now driving bolts of iron into the rocks, to bore cavities for the gunpowder for blasting. Scarcely had we recovered from the stupefaction occasioned by our first introduction into this *Pandæmonium*, when we beheld, close to us, hags more horrible than perhaps it is possible for any other female figures to exhibit, holding their dim quivering tapers to our faces, and bellowing in our ears. One of the same sisterhood, snatching a lighted splinter of deal, darted to the spot where we stood, with eyes inflamed and distilling rheum, her hair clotted with mud, dugs naked and pendulous; and such a face, and such hideous yells, as it is impossible to describe. If we could have heard what she said, we should not have comprehended a syllable: but as several others, equally *Gorgonian* in their aspect, passed swiftly by us, hastening tumultuously towards the entrance, we began to perceive, that if we remained longer in our present situation, *Atropos* might cut short the threads of our existence; for the noise of the hammers had now ceased, and a tremendous blast was near the point of its explosion. We had scarcely retraced with all speed our steps along the level, and were beginning to ascend the ladders, than the full volume of the thunder reached us, and seemed to shake the earth itself with its terrible vibrations."

The copper-mines of Cornwall are very numerous, and several of them large and rich in ore. In various parts of this county the earth has produced such an exuberance of this metal, as to afford it in large massy lumps of malleable copper, several pieces of which are shewn in very curious vegetable forms.

Cornwall has been, in all ages, famous for its numerous mines of tin, which are in general very large, and rich in ore. This ore is always found in a continued stratum, which the miners call *load;* and this, for the greater part, is found running through the solid substance of the hardest rocks, beginning in small veins near the surface, increasing as they proceed, into large dimensions, branching out into several ramifications. These loads, or veins, are sometimes white, very wide, and so thick, that large lumps of the ore are frequently drawn up of more than twenty pounds weight. The miners follow the load, or vein, in all its rich and meandering curves through the bowels of the flinty earth.

There are also numerous lead-mines in Great Britain, among which is that of Arkingdale, in Yorkshire, and those with which Shropshire abounds. In the south of Lanerkshire, and in the vicinity of Wanlock-head, Scotland, two lead-mines yield annually above two thousand tons of metal. The Susannah-vein, Lead-hills, has been worked for many years, and is considered as the richest lead-mine of Europe. A lead-mine in the county of Antrim, has yielded in 30 pounds of lead, a pound of silver. Another, less productive of silver, was found at Ballysadare, near the harbour of Sligo, in Connaught; and a third, in the county of Tipperary, 30 miles from Limerick.

At Ecton Hill, in Derbyshire, a valuable copper-mine was discovered some years ago, and has since been worked to great advantage. The works are four hundred and fifty feet beneath the river Dove, it being the deepest mine in Great Britain. On the opposite side of Ecton hill is a valuable lead-mine, the veins of which approach very nearly to the copper-mine.

The most important copper-mine in Britain is in the island of Anglesea, called Parys Mountain. It was discovered, a few years since, by a poor clergyman in the neighbourhood, who, in association with the Paget family, has realized incredible wealth from it. The external aspect of the hill is extremely rude, and it is surrounded by rocks of coarse white quartz. The ore is found in a basin or hollow, on one side of which is a small lake, whose vapours are fatal to birds that pass over it.—Whatever wealth it has brought to the proprietors, it has converted the rustic simplicity of the neighbourhood into a population having all the vices and savage appearance of persons in these unnatural employments; while the fumes of the burning piles of copper, have blasted the vegetation in every direction. The adjoining water becomes impregnated with the metal, and yields large quantities. No less than eight tons of gunpowder are employed annually, in blasting the rock.

A bed of clay has also been discovered, lying over the copper ore, containing lead, and a considerable portion of silver.

In 1751, a very rich copper-mine was wrought in the county of Wicklow, Ireland. From this mine ran a stream of blue-coloured water, of so deleterious a nature as to destroy all the fish in the river Arklow, into which it flowed. One of the workmen, having left an iron shovel in this stream, found it some days after encrusted with copper. This led to institute a series of experiments, from which it was ascertained that the blue water contained an acid holding copper in solution; that iron had a stronger affinity for the acid than copper; and that the consequence of this affinity was the precipitation of the copper, and the solution of the iron, when pieces of that metal were

Salt Mines near Cracow.

Silver Mine near Koningsburgh.

The importance of the manufacture of Cheshire salt is sufficiently obvious from the statement, that, besides the salt made for home consumption, which exceeds 16,000 tons, the average quantity sent yearly to Liverpool for exportation, exceeds 150,000 tons.

The general situation of rock-salt in Cheshire is very similar to that of the Transylvanian and Polish mines. The situation of the Austrian salt-mines near Saltzburg is, however, very different. The mineral there is disposed in thick beds, which occur near the summits of limestone hills, at a great elevation above the adjoining country.

The lead-mines of Upper Louisiana, in North America, have for many years been highly productive. That called Burton's mine is so extensive, that the mineral is calculated to cover two thousand acres of land. In other mines, in the vicinity of the above, the lead is found in regular veins, from two to four feet in thickness, containing about fifty ounces of silver in a ton; but at the depth of twenty-five feet the operations are impeded by water.

> Nor to the surface of enliven'd earth,
> Graceful with hills and dales, and leafy woods,
> Her liberal tresses, is thy force confined:
> But to the bowelled cavern darting deep,
> The mineral kinds confess thy mighty power.
> Effulgent, hence the veiny marble shines;
> Hence Labour draws his tools; hence burnish'd War
> Gleams on the day; the nobler works of Peace
> Hence bless mankind, and generous commerce binds
> The round of nations in a golden chain.

The following are the principal METALS and their characteristics, according to that able mineralogist Mr. John Mawe.

PLATINA, PALLADIUM, IRIDIUM. These substances generally occur in small irregularly formed grains, flat, angular, or blunted, having apparently acquired this form by attrition; rarely crystallized. They are found with granular gold, in Peru, Mexico, and Brazil. When associated, it requires, says Mr. Mawe, a well accustomed eye to discriminate one from the other. PLATINA occurs in considerable quantities, and sometimes in rough lumps, larger than a pea. It resembles silver in colour; it may be melted with arsenic, and is soluble in nitro-muriatic acid: when pure, it is the heaviest substance known.—*Sp. Gr.* 17; *purified*, 23. PALLADIUM is very rare, and is found with Platina, with which it is alloyed. It is delicately striated, and of a lead colour: it melts with sulphur.

IRIDIUM is extremely rare, and occurs with the preceding in small, flat, foliated grains, of a shining steel colour: it is alloyed with osmium, and melts with nitre.

GOLD occurs in rounded lumps of various sizes; also disseminated in quartz and ferruginous substances, but generally in dust of a yellow colour, and grains of irregular forms. It is also found crystallized in cubes, octohedrons, and many other forms, as well as foliated, ramified, capillary, reticulated, &c. It is very generally dispersed throughout the globe, and particularly in South America; also in Ireland, Scotland, Cornwall, &c. but is never found pure in its natural state. NATIVE GOLD is of a pale or deep yellow colour, and sometimes tarnished, according as it is less or more alloyed with silver or copper. It is always ductile, easily melted, and does not change colour in nitric acid. Its proper solvent is nitro-muriatic acid.—*Sp. Gr.* 17 *to* 19.

SILVER is rarely or never found pure; it is combined with many of the metals (particularly with lead) and two of the acids, which become volatilized by a continuance of the heat of the blowpipe, and a bead of pure silver will remain. It is soluble in nitric acid. The mines of this metal are very numerous, but the most productive are those of Mexico and Peru; it is met with in Devonshire and Cornwall, and has been found in Scotland. It is also extracted from lead. Its colour is nearly white, but is subject to tarnish resembling copper, and becomes blackish. It is ductile, a little harder than lead, and may easily be known by being soft and tough to the knife.—*Sp. Gr.* 10.

MERCURY generally occurs in a fluid state, and has a strong silver white lustre. Its presence in any of its ores may be easily detected, by heating a small portion under a gold coin, or plate of polished copper; the mercury will be volatilized by the heat, and condensed by the cold metal, to which it will adhere in minute globules. The ores of mercury are confined to a few localities, but wherever they have been found, they occur in great abundance. The principal mines are situated in Almaden, Deux-Ponts, Idria, and South America. NATIVE MERCURY occurs in minute or large globules, also disseminated in cinnabar, clay-slate, bituminous schist, sand-stone, &c.—*Sp. Gr. above* 13.

COPPER is in such general use, that it is unnecessary to describe its appearance or colour. It is easily dissolved in nitric acid, to which it communicates a green colour, and may be precipitated in a metallic state, by a rod of iron. The ores of copper are very numerous, and are found in almost all parts of the world, particularly in Cornwall and Chili. When alloyed with zinc, it forms brass. Silver and gold coin are debased by it, and of jeweller's gold it often forms the greatest proportion.

NATIVE OR VIRGIN COPPER occurs massive, disseminated, and crystallized, and in a variety of other forms. It has a bright or dark red colour, as it is less or more tarnished. It is extremely ductile, always soft to the knife, and if scratched exhibits a bright metallic lustre. It is found in great abundance in the mines of Cornwall, as well as in Chili, where it is accompanied by a small portion of gold.—*Sp. Gr.* 7.

COPPER PYRITES occurs in great abundance, massive, disseminated, stalactitic, and crystallized, of a pale yellow colour. It is harder and more difficult to melt than the preceding, but is easily dissolved in nitric acid. It contains from nine to twenty-five or thirty per cent. of copper, with iron, sulphur, and sometimes arsenic.

IRON is so generally distributed, that there are but few substances into which it does not enter, or associate with. It is found in all countries, in a variety of forms, and of different colours. Its presence may in general be detected by the magnet, especially after having been exposed to the flame of the blow-pipe or a red heat. NATIVE IRON *is said* to have been met with massive, and in plates of a grey colour, with a granular fracture, soft and malleable. Of this ore there are two varieties—*Terrestrial Native Iron*, which is feebly malleable, and *Meteoric Native Iron*, which is found in large lumps, and coating earthy substances, of a rusty brown exterior. Its streak has a shining metallic lustre, and the fracture exhibits delicate, bright foliæ. These varieties are strongly magnetic, and contain nickel. IRON PYRITES occurs in great abundance, massive, crystallized, &c. It is brittle, and hard to the knife. The colour is of various shades of yellow, tarnished, and sometimes beautifully irridescent.

Iron, the most truly useful of all metals, presents itself abundantly, and in a great variety of forms. In a native state, it appears to consist of meteoric iron, or that which has descended to the ground in showers of stones. These masses of meteoric iron are found dispersed through every quarter of the globe, and the phenomenon of their fall has occurred not unfrequently in different parts of Europe.

A mass of this description of iron was discovered in the district of Santiago del Estero, in South America, by a party of Indians, in the midst of a wide extended plain. A fibrous kind of native iron has been found at Eibenstock in Saxony, and also in Siberia, where one particular mass weighed 1600 pounds. It resembled forged iron in its composition, and was malleable when cold, but brittle when red hot.

The forms, however, in which iron appears most extensively, are the different species of pyrites, of iron-stone, of iron ore, the chromate, and arseniate of iron. The most extensive iron-mines in the world are situated in Great Britain and France, in the form of clay iron-stone. Sweden contains large mines of magnetic iron-stone. Extensive iron-mines are also found in Russia, in Germany, particularly in Austria, in the United States of America, and in Spain.

Some enormous masses of native iron have also been found in Brazil; and near Lake Superior; all, according to Sir Richard Phillips, so many accessions to our planet collected as it flows through space in its annual orbit.

NATURAL LOADSTONE is an oxide of iron, massive, compact, earthy, and strongly magnetic. Its colour is black or brown.

The ores of MANGANESE present great diversity in external characters; but its presence in any substance may easily be detected by melting it with borax and a little nitre, which will form a violet glass. It is much used in the arts, particularly in bleaching, in making glass, and for producing oxygen gas. It is generally combined with oxygen, and more rarely with sulphur, and carbonic or phosphoric acids. It occurs in great abundance in Devonshire, Cornwall, Derbyshire, and Scotland, often associated with ores of iron.

LEAD is one of the most abundant of metals, and occurs in large and small veins, in almost every rock formation, combined with sulphur, oxygen, and many of the acids, and generally contains silver. The ores of lead are easily reduced by the blow-pipe, and dissolved in nitric acid. Its uses in the arts are numerous and well known. There are many mines of this metal in England; the principal are situated in Northumberland, about Alston Moor; Durham; the West Riding of Yorkshire; Matlock, and throughout the Peak in Derbyshire. Devonshire and Cornwall are particularly rich in silver.

The ores of ZINC, are generally found associated with lead. They are combined with sulphur and oxygen, and with carbonic and sulphuric acids. From the external appearance of some of the ores, the presence of a metal would not be suspected; but it may readily be discovered by first roasting the ore, and then fusing it with copper filings, with which it will form brass:—this is one of the uses to which this metal is applied.

TIN contains only three species; its localities are not numerous, but wherever it has been found, it occurs in abundance. It is fused with difficulty. SULPHURET OF TIN occurs massive and disseminated; its colour approaches steel-grey, with shades of yellow, and has a metallic steel lustre. It is peculiar to Cornwall, and is often called *Bell-metal Ore.*

OXIDE OF TIN is found massive, disseminated, and crystallized, also in rounded lumps, when it is called *Stream Tin*: its colour is dark brownish black, and it is extremely heavy. *Wood Tin* occurs in small mammillated masses, has a diverging, fibrous structure: its colour varies from red to brown. It is very heavy, and occurs in alluvial soil.

BISMUTH is not in great abundance; it occurs in veins with silver, cobalt, arsenic, &c. It is extremely easy of fusion, and is used in making pewter, solder, &c.

TELLURIUM has only been found in Transylvania, where it occurs in delicate veins, and is alloyed with gold, silver, &c. Its lustre varies from bright to that of tarnished iron. In nitric acid it forms a limpid solution, and easily melts before the blow-pipe, emitting a peculiar pungent odour.

ANTIMONY is found in veins, and generally accompanied by blende. It often resembles galena, but is not so heavy: it is mineralized by arsenic, sulphur, and oxygen; it easily melts, and discharges thick white vapours. It is used in type-metal, and in various medicinal preparations.

The ores of COBALT are found in primitive and alluvial formations. Before the blow-pipe it emits arsenical vapours, and tinges borax intense blue. It is used in enamel painting, &c. It is found in Cornwall, but the best varieties are imported from Sweden and Saxony.

NICKEL is not very abundant. It is found in combination with meteoric iron, and associated with copper. It is difficult to melt, and emits arsenical fumes; it gives a green colour to nitric acid. With copper it forms *Petit Or.*

ARSENIC is very generally diffused. It is found combined with sulphur and oxygen, and often enters into ores of other metals, which have been already described. The odour of garlic, which it emits when struck with a hammer, or heated before the blow-pipe, together with its *rapid* volatilization, distinguish it from other metallic ores.

TUNGSTEN is found combined with oxygen, lime, and iron. It is associated with tin in primitive rocks, is fusible before the blow-pipe, and nearly insoluble in the acids. It is extremely heavy.

CHROME has only lately been found in the state of an oxide. It occurs massive or earthy, of a dull green colour. It is with difficulty reduced to a metallic state; to glass it communicates a bright and permanent green.

Several earthy minerals have been noticed in the Lecture on Precious Stones; but it may be proper here to notice some others.

The varieties which compose the CLAY FAMILY of minerals have an earthy fracture, and emit an argillaceous smell when breathed upon; they are never found in any regular form: the colours are dull.

COMMON CLAY—*Loam*, is of a yellowish grey colour; it occurs massive, and sometimes indurated; it is an alluvial deposit; it adheres strongly to the tongue.

Potters' Clay. Its colours are greyish or yellowish white; it occurs massive, sometimes slaty, and semi-indurated; it is the common clay of which earthenware, pipes, &c. are made.

CLAY SLATE. Its colours are various, from grey to black or red. It occurs massive, and is frequently traversed by delicate veins of tin. With the common variety of this substance houses are slated.

DRAWING SLATE is of a black colour; it occurs massive and compact; it is used for crayons.

Rotten Stone, has a dull brown colour; it occurs earthy and friable; it is probably a decomposed limestone, or alluvial deposit.

Porcelain Earth is generally of a white colour; it occurs massive and compact; it is probably a deposit of decomposed feldspar, silica, &c.

Alum Stone is of various colours, generally greyish or reddish white; it occurs massive and porous; it is brittle, and is found in volcanic craters.

Slate Clay. Colour approaching black; it occurs massive, and has a slaty or earthy structure; it is soon decomposed. It generally contains vegetable impressions.

The principal characteristic of the MICA FAMILY, is its foliated and glistening appearance, sometimes approaching splendent; it has a tendency in all its crystallizations to the hexagonal form; it is difficultly fusible before the blow-pipe.

MICA is of various colours, but generally white, grey, brown, or black; it occurs massive, disseminated, and crystallized; it is easily divisible into the finest liminæ, which are perfectly flexible.

Among the SOAP-STONE FAMILY are NATIVE MAGNESIA, of a white or greyish white colour; it occurs massive; fracture, foliated or radiated; it is soft, and adheres slightly to the tongue. FULLERS' EARTH has a greenish-grey colour; it occurs massive, and has a dull earthy appearance; it falls into powder in water; it is friable. STEATITE, or *Soap-stone*, has a mottled soap-like appearance; it occurs massive, and in pseudo-morphous crystals; it is generally soft, sometimes indurated, and has a greasy feel.

The TALC FAMILY presents great diversity in colour, texture, and general appearance; they all contain a large portion of magnesia.

SERPENTINE has a dull colour, generally green, brown, white, or red, often intermixed in the same specimen; it occurs massive; it frequently contains veins of asbestos, and some varieties have so large a portion of iron as to be magnetic.

ASBESTOS. Its colour is greenish-white or grey; it occurs massive, in delicate veins, and frequently disseminated in calcareous spar, quartz, &c. *Amianthus* is a fine variety of the preceding, and has a silky lustre; it is composed of delicate flax-like fibres. *Amianthoide* has an olive-green colour; it occurs in filaments, accompanied by carbonate of lime, feldspar, quartz, &c. It is flexible and elastic.

The *Asbestos* is so named because of its *not perishing* in fire. The fibres are slightly flexible, and often form stiff and brittle needles, in which, however, we find only magnesia, silica, and oxide of iron. Human ingenuity has manufactured this mineral into paper and cloth. The Scythians dressed their dead bodies, which were to be burned, in a cloth manufactured of this stone. The Romans also enclosed dead bodies in cloth of this kind. A large piece of asbestos cloth has been found in a tomb, with the ashes of a Roman. Pliny informs us that this kind of cloth was as much valued as the richest pearls; and that napkins thereof taken from table, were cleansed in the fire instead of washing. The Persians make wicks of it for their perpetual lamps. But the chief use of the asbestos cloth was for shrouds at royal funerals, to wrap the corpse when placed on the pile, and so preserve the ashes distinct from those of the wood which formed the funereal pile.

The *Amianthus* has a silky texture, and pearly aspect. Of this mineral the ancients made their incombustible flax, and in Russia they still knit the silky amianthus of Mount Oural. It is found in plates, and massive; of a greenish white, and also of a blood-red colour; rather greasy to the touch; and melts with difficulty. The *Amianthoid*, or false amianthus, is a variety; and also the *Fossil Leather*, found in the iron-mines of Sweden, of a whitish colour, and of the thickness and consistence of tanned horse's skin.

Rock Cork has a greyish or cream-like colour; it occurs in laminar masses, with a porous structure; some varieties very much resemble leather. *Rock Wood* has generally a wood-brown colour; it occurs massive and compact, and has a ligneous appearance.

The HORNBLENDE FAMILY contains many minerals which are soft to the knife, and when abraded of a dull greenish hue.

The CHRYSOLITE FAMILY is composed of substances whose general colour is green or black: the crystallizations are commonly derived

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VIEW OF STAFFA from the SOUTH WEST.

from the four-sided prism; they have a foliated structure, and generally a vitreous lustre.

The BASALT FAMILY, containing, 1, BASALT, has a dull blackish colour; it occurs massive, in large columnar prisms. 2. WACKE is of a grey or brown colour; it occurs massive and vesicular. 3. AMYGDALOID is a variety of wacke, having the cells filled with zeolite, green earth, calcareous spar, &c. 4. CLINK-STONE is green of various shades; it occurs massive and compact; it has a slaty structure, and rings when struck with a hammer, whence its name.

The formation of basaltes has produced combinations which constitute some of the greatest wonders of nature. Thus, in Ireland they produce the *Giant's Causeway*, a vast collection of basaltic pillars in the vicinity of Ballimony, in the county of Antrim, Ireland. The principal, or grand causeway, (there being several less considerable and scattered fragments of a similar nature,) consists of an irregular arrangement of many hundred thousands of columns, formed of a black rock, nearly as hard as marble. These columns are of an unequal height and breadth: several of the most elevated, visible above the surface of the strand, and at the foot of the impending angular precipice, are of the height of about twenty feet, which they do not exceed, at least not any of the principal arrangement.

This grand arrangement extends nearly two hundred yards, as it is visible at low water; but how far beyond is uncertain: from its declining appearance, however, at low water, it is probable that it does not reach beneath the water to a distance equal to that which is seen above. The breadth of the principal causeway, which runs out in one continued range of columns, is in general from twenty to thirty feet: in some parts it may, for a short distance, be nearly forty.

The figure of these columns is, with few exceptions, pentagonal, or composed of five sides; and the spectator must look very narrowly indeed to find any of a different construction, having three, four, or six sides. There are not two columns in ten thousand to be found, which either have their sides equal among themselves, or display a like figure.

The columns or pillars, are composed of several short lengths, nicely joined, and articulated into each other like a ball and socket, or like the joints in the vertebræ of some of the larger kind of fish. The length of these particular stones, from joint to joint, is various; in general from eighteen inches to two feet long; and, for the greater part, longer towards the bottom of the columns than nearer the top.

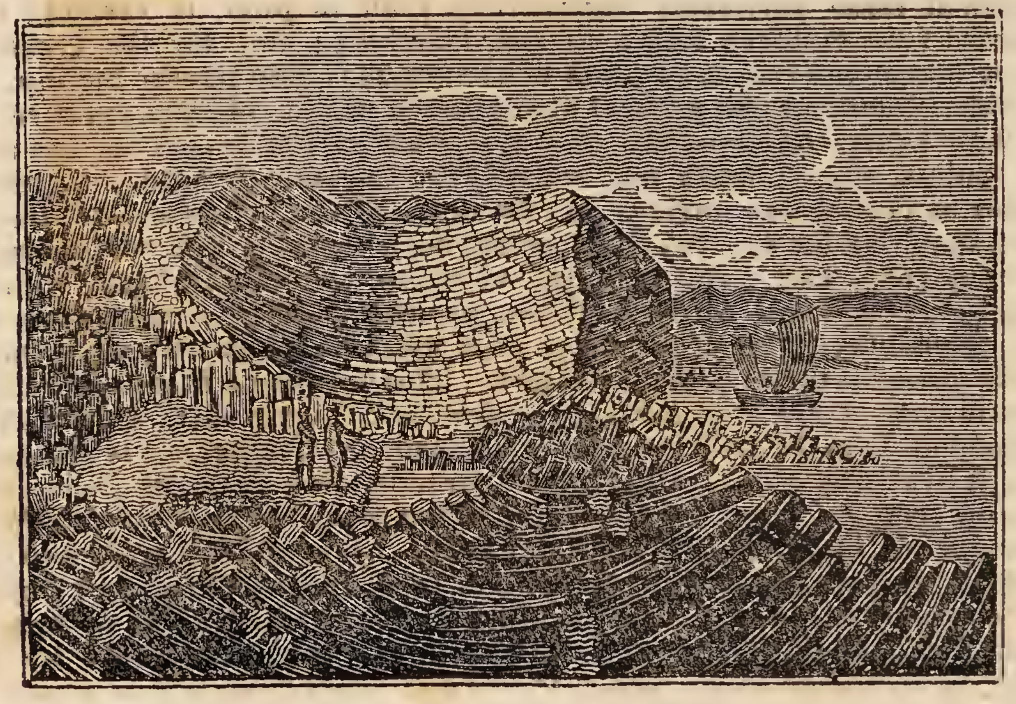
Notwithstanding the general dissimilitude of the columns, relatively to their figure and diameter, they are so arranged and combined at all the points, that a knife can scarcely be introduced between them, either at the sides or angles. At the depth of ten or twelve feet from the summit of the cape of Bengore the rock begins to assume a columnar tendency, and forms a range of massy pillars of basalt, which stand perpendicular to the horizon, presenting, in the sharp face of the promontory, the appearance of a magnificent gallery or colonnade, upwards of sixty feet in height. This colonnade is supported on a solid base of coarse, black, irregular rock, nearly sixty feet thick, abounding in blebs and air-holes; but, though comparatively irregular, it evidently affects a peculiar figure, tending in many places to run into regular forms, resembling the shooting of salts and many other substances during a hasty crystallization. Beneath this great bed of stone, stands a second range of pillars from forty to fifty feet high, more exactly defined, and emulating, in the neatness of its columns, those of the Giant's Causeway. This lower range is upborne by a layer of red ochre stone, which serves as a relief to shew it to greater advantage. The two admirable natural galleries, with the interjacent mass of irregular rock, form a perpendicular height of one hundred and seventy feet, from the base of which the promontory, covered with rock and grass, slopes down to the sea a considerable space, so as to give an additional height of two hundred feet, making in all nearly four hundred feet of perpendicular elevation, and presenting a mass, which for beauty and variety of colouring, for elegance and novelty of arrangement, and for the extraordinary magnitude of its objects, cannot, perhaps, be rivalled by any thing at present known.

Near Padua, there are several basaltic columns, similar to those of the Giant's Causeway, although less magnificent in appearance.

At a short distance is another basaltine hill, called *Il monte del Diavolo*, or the Devil's Hill, along the sides of which the prismatic columns are arranged in an oblique position. This causeway extends along the side of the vale beneath, nearly with the same arrangement of the columns as is displayed on the hill. The length of the columns of the Monte del Diavolo cannot be ascertained, as they present their summits only to the view: their remaining parts are deeply buried in the hill, and in some places entirely covered.

The texture and quality of these columns are not less different than their forms. Those of the Monte del Diavolo present a smooth surface, and, when broken, appear within of a dark iron-grey colour, manifesting also a very solid and uniform texture; in which characters they correspond with the columns of the Giant's Causeway, and those of most other basaltic groups. But the columns of Monte Rosso are in these respects very different, they having not only a very rough, and sometimes knotty, surface, but displaying likewise, when broken, a variegated colour and unequal texture of parts. They are commonly speckled, more or less distinctly, and resemble an inferior sort of granite, of which Monte Rosso is itself formed, and which serves as a base to the range of columns in question.

This formation extends from the Giant's Causeway to the opposite shores of Scotland, and includes the famous island of Staffa and Fingal's Cave, already described. But basalt presents other forms, and proves that it once was liquid by a vast collection of CURVED OR BENT PILLARS, which present themselves on one side of Staffa, as in the engraving.



Giants Causeway of Basaltic Pillars in Ireland.

The LIMESTONE FAMILY are universally diffused. Independently of their use in the arts, they contribute largely to the fertility of the soil; and their chemical agencies are essentially beneficial to animal and vegetable life: they consist of, 1. TABULAR SPAR, a greyish white colour; occurs massive and crystallized, often disseminated in Cinnamon-stone; it is hard and brittle; in nitric acid it effervesces for a moment, and then granulates. 2. SLATE SPAR. Its colour is white of various shades; occurs massive and disseminated, also in distinct concretions, and lamellar; it has a pearly lustre, and slaty fracture. 3. CHALK. Colour is snow-white; occurs massive and disseminated. 4. COMMON LIMESTONE. Colour grey; occurs massive and compact; it burns to lime, and effervesces in acid. 5. *Oolite*, of a yellowish brown colour; occurs massive, composed of minute globular concretions, resembling the roe of a fish. 6. *Granular Limestone* or *Marble*, of a white colour, and occurs massive; it is much used in the arts for statuary, &c. *Tiree Marble*, of a flesh-red colour; it often contains sahlite and titanium imbedded in it. 7. *Mona Marble* has a white and green colour, and much resembles verde antique. 8. *Shell Limestone* is of various colours, generally dark; it is composed of fossil shells. 9. *Fire Marble*, is a variety of the preceding; it is composed of shells, which have a brilliant opalescent lustre. 10. *Coralloid Limestone* is generally of a dark colour; it is found massive, and composed of corals, zoophites, &c.; some varieties much resemble madrepore. 11. *Calcareous Spar.* The crystallizations of this substance far exceed those of any other in number, beauty, and complexity. There are 650 varieties arranged in three divisions, arising, 1st, from the acute six-sided pyramid (primitive rhomb); 2d. the six-sided prism; and 3d. the three-sided pyramid; and so beautiful is the connexion, that the termination of the third series gradually approaches the first, forming, as it were, a complete circle. The colour is generally yellowish white; the transparent variety exhibits double refraction. 12. *Fibrous Limestone—Satin Spar*, is snow-white; it occurs massive and compact, composed of short aggregated fibres; it is often associated with pyrites. 13. *Stalactite* has a white, yellow, green, or brown colour; it occurs massive, botryoidal, reniform, &c. it is formed by precipitation, and hangs like icicles from the roofs of caverns. 14. *Black Marble.* Its colour is intense black; it is capable of receiving a very high polish, and is in much estimation for vases, chimney-pieces, &c. 15. MARL is of various colours, generally greyish-white; it occurs massive, and frequently contains impressions of fish and dendritic appearances. 16. ARRAGONITE. Its colours are white, yellow, or grey; it occurs massive, crystallized, arborescent, and stalactitic, with a fibrous structure, and pearly lustre; it is sometimes imbedded in granular gypsum.

Of marbles, there are so many diversities, that no mineral affords more, nor has more attracted the attention of mankind.

Tables of elastic marble are an extraordinary species of fossil. Being set on end, they undulate backward and forward; when laid horizontally, and raised at one end, they form a curve, beginning towards the middle; but if placed on a table, with any thing laid under them, they make a salient curve, and both ends touch the table. Dr. Mitchell, of New York, has a specimen of American elastic marble, 5 feet long, 22 inches broad, and 2 inches thick; making a mass of 2640 cubic inches. When shaken it undulates to and fro: when the extremities are supported, the middle forms a curve of about 2 inches, from an horizontal line; and when turned over, it recovers and inclines as much the other way. Many beautiful varieties of marble, are found in the British islands.

The substances of the FLUOR FAMILY are composed of fluoric acid and lime; when powdered and digested with sulphuric acid, the fluoric acid escapes in the form of gas. By means of this acid the beautiful operation of etching upon glass is performed. It decrepitates on the application of heat, and becomes phosphorescent when thrown on hot coals.

1. COMPACT FLUOR has a blueish-grey, or greenish-white colour; it is found massive, and gives a white streak with the knife; it is of rare occurrence. 2. EARTHY FLUOR. Its colour is light purple or deep blue; it occurs massive, and coating the other varieties; it is very friable and sometimes striated. 3. ARGILLACEOUS FLUOR is of a brown colour: it occurs in small detached cubes, and is generally found in decomposed amygdaloid.

The GYPSUM FAMILY, when calcined, forms plaster of Paris; the translucent varieties become opaque in the flame of a candle.

In the BARYTE FAMILY there are but two species. Carbonate and Sulphate of Barytes are distinguished from other earthy substances by their great weight.

The INFLAMMABLE MINERALS are NATIVE SULPHUR, which has a bright yellow colour; it occurs massive, disseminated, and crystallized; the finest varieties are from Coneil in Spain: and VOLCANIC SULPHUR, colour yellow, of various shades; it occurs stalactitic, spongeous, and granular; also in aggregated crystals.

The BITUMINOUS FAMILY consists of NAPTHA. It is composed of carbon, hydrogen, and oxygen; it takes fire at the approach of flame. PETROLIUM is reddish or blackish brown; it is thick, floats on the water, and may be seen oozing from various strata. It is sometimes precipitated on limestone. And ELASTIC BITUMEN. Colour blackish, greenish, and yellowish brown; it occurs massive, filling holes in limestone; it is peculiar to Castleton, Derbyshire.

The COAL FAMILY has been previously noticed.

COMPACT PLUMBAGO is used for pencils, crayons, &c. It is known better by the name of black lead.

The RESIN FAMILY are, AMBER. Colour, yellow, or yellowish white, and reddish; it occurs in rounded pieces, with a rough exterior, sometimes decomposed. It is found on the Norfolk coast. The variety from Mozambique often envelops insects.

HONEY STONE has a yellow colour; it occurs imbedded in grains, or crystallized in flat octahedrons in brown or wood coal, and is very rare.

RETIN ASPHALT. Colours, yellowish and reddish brown; it occurs massive; it burns with a fragrant odour. It contains resin 55, asphalt 42.

FOSSIL COPAL. Its colour is yellow or brown; it occurs in rounded pieces, and it appears to be a variety of retin asphalt, but approaches more nearly to gum; it has sometimes a resinous lustre.

The EARTHY SALTS are, NATIVE ALUM. It has a white colour, and occurs stalactitic, efflorescent, and in capillary crystals. It contains alumina, 18, oxide of iron from 5 to 10, with sulphuric acid and water. EPSOM SALT is white of various shades; it occurs massive and tuberose; it contains sulphuric acid 33, magnesia 19, and water.

The TREATMENT of the ORES, the REDUCTION of METALS, and the processes for refining them, have been for ages conducted with perfection, but are operations of labour and difficulty. All the ores are much mixed with earthy matter, even after washing. Volatile substances enter in most cases into the composition of the ores, as sulphur, arsenic, and carbonic acid; and other substances also are found combined with the metals, which cannot like them be simply evaporated, but must be first separated by the addition of other bodies with which they combine.

The working of gold and silver mines is the tomb of the greater part of those who labour in them. It destroys all the social and domestic virtues; supports debauchery and dissipation, with all the vices that follow in their train; and creates poverty and vagrancy, disgorging into society the exhausted and worn-out workmen.

The processes which are employed are, calcination or roasting, fusion or melting, and refining, which operations require the application of heat; and in most of them it is urged to great intensity.

The furnaces employed are of two classes:—*Blast furnaces,* where the fire is excited by the use of bellows or air cylinders constantly working; and *air furnaces,* where the effect is produced by strong draught, occasioned by the height or construction of the stacks or chimneys. Calcination of copper, lead, and tin ores is performed in reverberatory furnaces, at a moderate red heat. In copper works, each furnace contains full three tons of raw ores, which are frequently turned, to expose fresh surfaces, for twelve hours. Lead ores are treated in the same manner, in the same furnace often, which with a higher heat is used to melt them, and the charge seldom exceeds a ton.

Tin ores are roasted or calcined, principally to alter the specific gravity of the pyrites with which they are mixed, which thus is separated by subsequent dressing or washing. Iron ores are roasted to free them from the sulphur; the ore is stratified with refuse coal, and burnt in large heaps in the open air.

The fusion of *copper* ores is conducted in reverberatory furnaces at a high degree of heat, and the slag is raked off in a fluid state. *Lead* and *tin* ores are treated in nearly a similar manner. *Iron* smelting is carried on in blast furnaces of very large dimensions, in which coke is employed as fuel, and limestone is used as a flux. Copper of the first flowing is in part combined with sulphur, so as to require subsequent calcinations and repeated fusions before it comes to the refining process.

The mode of extracting the precious metals most in use in Hungary and other parts of Germany, as well as in all the American mines, is that of *amalgamation* of the ores with mercury. By this process the gold or silver is dissolved by the mercury, and separated from the earthy mixture, and also from the baser metals which do not so readily combine with the mercury. Subsequent distillation then separates and preserves the mercury, and the gold or silver is refined in the usual way.

The most important metals produced in Great Britain are: Iron, Copper, Lead, Tin.

The manufacture of iron may be computed at	per annum.
Wales	150,000 tons.
Shropshire and Staffordshire	180,000
Yorkshire and Derbyshire	50,000
Scotland and other places	20,000
at £5 per ton.	400,000

The quantity of copper raised in 1822, was about 10,000 tons, (which, however, was less by near 1000 tons than the preceding year,) of which, about 8000 tons are produced in Cornwall; the value of which, in its unmanufactured state, is about one million.

The lead of Great Britain amounts to from 30 to 32,000 tons, worth £25 per ton.

Tin is only found in Cornwall and Devon, and the quantity fluctuates from 2800 to 5000 tons in the year; the whole value is about £400,000.

MINERAL WATERS are divided into four classes, the *acidulous*, the *sulphureous*, the *chalybeate*, and the *saline*.

Acidulous waters are those which contain carbonic acid in its free state, or in combination in excess with a base. These waters are easily distinguished by their slightly acid taste, and by their sparkling when poured from one vessel to another; both of which properties they lose, when exposed to the air for a length of time, or by boiling. Besides carbonic acid, they almost always contain muriate of soda, and some of the earthy carbonates; it is the free carbonic acid, however, that imparts to them their particular properties.

Sulphureous waters are those which contain sulphuretted hydrogen. These are very easily distinguished by their odour, and by their rendering a solution of a salt of lead black, or by causing a piece of silver, when immersed in them, to acquire a dark colour. Besides sulphuretted hydrogen, they in general contain alkaline and earthy sulphates and muriates. The sulphureous waters may be subdivided into two kinds; 1st. Those which have sulphuretted hydrogen in its free state: 2d. Those in which it exists in union with an alkali or an earth.

Chalybeate waters are those which have iron as an ingredient. These are known by their peculiar taste, and by their becoming black when mixed with an infusion of nutgalls. The chalybeate waters are of different kinds; sometimes the iron is combined with sulphuric acid, more frequently it is in union with carbonic acid; this may be just in sufficient quantity to hold the iron in solution, or it may be in excess; in which case, besides chalybeate, the water possesses acid properties, forming what is called an acidulous chalybeate water.

Saline waters are those which contain the saline ingredients generally found in mineral waters, but which have not carbonic acid in excess, and are free from sulphuretted hydrogen and iron, or contain them in very trifling quantity. Saline waters may be subdivided into four kinds. *Alkaline waters*, or those which contain alkali in its free state, or combined with carbonic acid, and which render the vegetable blues green. *Hard waters*, or those which contain carbonate or sulphate of lime. *Salt waters*, or those in which muriate of soda abounds. *Purgative waters*, or those which contain principally sulphate of magnesia.

LECTURE XXIX.

EXTRANEOUS FOSSILS, OR ORGANIC REMAINS.

> There are more things in heaven and earth
> Than are dreamt of in our philosophy. SHAKSPEARE.

FOSSIL REMAINS, sometimes called Organic Remains, are the remains of vegetables and animals, which have been involved within earthy aggregates during the changes of position and composition, to which they have been subject, in the progress of time, from the action of water and air, and from their mutual actions on each other.

Animals, fishes, and vegetables, are found beneath the surface, every where and at all depths. Sometimes in loose soil, at other times lying in strata, and frequently imbedded in solid rocks. They afford palpable evidence that the whole surface of the earth has been overturned and mingled; destroyed in one form, and renewed in the present form. Their successive layers prove also that these overturnings have occurred in various ages, remote from one another, and possibly as remote from each other, as the last overturning has been from the age in which we live. Their exotic characters, too, in every country, prove that the climates, or the relative positions of the earth's surface to the sun, have also been changed; and, in a word, that revolutions of all kinds have taken place, in regard to our planet, in ages too remote for record.

When fossil organic remains first engaged the particular attention of naturalists, it was believed that they were irregularly distributed throughout the different formations of which the crust of the earth is composed, and that the whole had been deposited from the waters of the Deluge. It was soon, however, ascertained, that some rock formations never contain petrifactions; a fact which gave rise to the opinion, that fossil organic remains were confined to one set of rocks, the secondary, in which they were jumbled together in an irregular manner, while they were entirely wanting in the formations of the primitive class. The more accurate investigations of geologists, particularly those of the school of Werner, have not only proved the insufficiency of former views, but given a new character to the whole subject.

It has been shown by these inquiries, 1. That petrifactions, or fossil organic remains, do not occur in primitive rocks, but first appear in rocks of the second, or Transition class. 2. That these organic remains are, in general, more altered, or mineralized, in the older than in the newer formations; so that they appear much changed in transition rocks, and scarcely at all altered in the rocks of the newest, or alluvial class. 3. That these remains are so arranged under the surface of the earth, that those of the more simple animals and plants appear first, or in the oldest rocks; while in rocks of a middle age, the remains are of animals higher in the zoological and botanical scales; and in the newest rocks, the fossil organic remains are of the more perfect animals, reaching even to man. 4. That the fossil organic remains in transition, secondary, and diluvial formations, are in general different from those of the present creation; but that, in post-diluvial formations, the remains are of recent species of animals and vegetables. 5. And lastly, that although these fossil animals and plants, in general, differ from those of the present world, we observe that they approach nearer and nearer, in appearance, to those of the recent tribes, the newer are the formations in which they are found; so that, in the latest formations there is an absolute identity of character, proving that the fossil species are the same as those now existing.

The primitive rocks, as already mentioned, appear

Fossils, Shells, &c.

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to have been formed before the organic varieties were called into existence; because they contain neither animal nor vegetable remains. It is in the transition rocks that organic remains first make their appearance; showing, that at their formation, and not earlier, animals and vegetables began to exist; and thus nearly establishing one of the most remarkable and striking facts in the whole range of geological science. For a long period, the organic productions of the earth appear to have been principally marine; as in all the formations, extending from the transition class to the chalk, inclusive, corals, shells, encrinites, echinites, fishes, and marine oviparous quadrupeds, are the predominating fossil animals; and hence the different rocks of those formations must have been formed under the waters of the ocean. But the strata of the coal formation contain, besides marine organic remains, land plants and land shells; and the bituminous marl slate, principally fresh water fishes; facts which lead to the conclusion, that fresh, or land-water, was concerned in their formation. The formations extending from chalk to the alluvial series, from their containing abundant remains of both marine and fresh water animals, show that the waters of the land and the ocean assisted in the formation of these rocks. And lastly, from the diluvial formations containing the remains of so many extinct quadrupeds, &c., we have sufficient evidence of their formation in the action of the waters of the ocean, while the post-diluvial clays, sands, and gravels, with their fossil remains of known plants and animals, are formations daily taking place upon the land, and under the sea.

Not long after the commencement of the Christian era, attempts were made, say the Editors of the Encyclopædia Britannica, to connect these phenomena with the Deluge of Noah; and in the writings of Tertullian, there are passages that refer to this supposed connexion. But the non-occurrence of the remains of man along with those of other animals is considered as inimical to this opinion, and it is nearly abandoned. Another speculation was soon started in its place, by which it was attempted to show that these remains were not truly organic, but merely efforts of Nature to produce organic beings; and, therefore, that these bodies, although exhibiting the organic form, had never been animated. This fancy was combated by the supporters of the diluvian hypothesis, and the result was, the addition of many new facts, and the total abandonment of both hypotheses.

Fossil organic remains occur either unchanged, or more or less altered from their original state or condition, by the removal of some of their constituent parts, their bitumenization, or owing to impregnation with various mineral substances. Shells, bones, teeth, vegetables, of various descriptions, in some alluvial soils, are scarcely at all altered, and remains of quadrupeds have been found well preserved in ice in polar countries; and in peat-mosses, human bodies remain uncorrupted for a long series of years. Shells are sometimes found in a nearly unaltered state in solid rocks, as limestone. The beautiful fire marble of Carinthia contains unaltered shells of ammonite, with their pearly lustre, and rich tints of the most beautiful colours. Shells and bones occur in other alluvial strata, more or less bleached, being dry and fragile, owing to the removal of a portion of their animal matter. In fossil fishes, sometimes not only the bones, but also the soft parts, and even the scales, occur more or less perfectly preserved. Fossil vegetables occur, either nearly unaltered, or more or less bitumenized or carbonized, in alluvial strata, also in the brown-coal formation, and in some sandstones. In other cases, the animals or vegetables have disappeared, and only their casts, or impressions, remain to attest their former presence. This change is more frequent with vegetables than animals. In particular situations, the organic body, whether plant or animal, is simply coated, or incrusted, with the mineral matter, and but slightly impregnated with it. The incrusting matter is most frequently calc tuff and calc sinter, less frequently volcanic tuff. But the most durable state of fossil organic remains is the *petrified*, when they are more or less completely impregnated with mineral matter.

Fossil seeds and fruits of plants occur in different

Fossils, Plants in Stone and Coral.

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formations, but usually in such a state as renders it nearly impossible to determine the tribes to which they belong. Faujas St. Fond found fossil fruits in the brown coal of Liblar, which, he said, bore a strong resemblance to areca nuts; an opinion in which he was not supported by the after examination of Jussieu, Desfontaines, Lamarck, and Thouin. They probably belong to some palm. The fossil seeds that occur in bituminous wood, in which amber also is found, cannot be referred to any known plants. In the Island of Sheppey there are accumulations of seeds, some of which are like those of the palm, others the chesnut, and cocoa, but none identical with any of these.

Trunks, branches, and roots of trees, occur in rocks of different kinds, or even loose, more or less impregnated or petrified with mineral matter. The structure and external form are sometimes well preserved, and in other cases both are nearly obliterated. Hitherto no accurate descriptions have been published of the internal structure of these petrifactions, and consequently the names given to them are not to be depended on. Thus it is said that oak, birch, pine, box, elm, willow, hazel, ash, occur petrified in the form of wood-stone and wood-opal; but our own experience does not go to confirm these determinations.

Trunks, branches, and roots of trees and shrubs, are sometimes impregnated with hornstone, forming what is called wood-stone, or ligneous hornstone, and this is one of the most frequent of the petrified woods. The wood appears, in some cases, to have been in a rotten state when petrified, and such varieties appear light coloured and shivery; in other cases, it appears first to have been bitumenized, so that it is both bituminous and siliceous together, in which case it is of a dark brown or black colour, and of a more compact texture. There are several specimens to show the combination of siliceous matter and bituminous wood in its different stages of bitumenization. Lastly, in other cases, the wood appears to have undergone no change, and then, the wood, or at least part of the ligneous matter, remains in the petrifaction, while, in others, the whole has disappeared, leaving nothing but its form behind. It is probable, however, that many wood-stones, in collections, are not real petrifactions, but portions of trees in which a great secretion of silica has taken place.

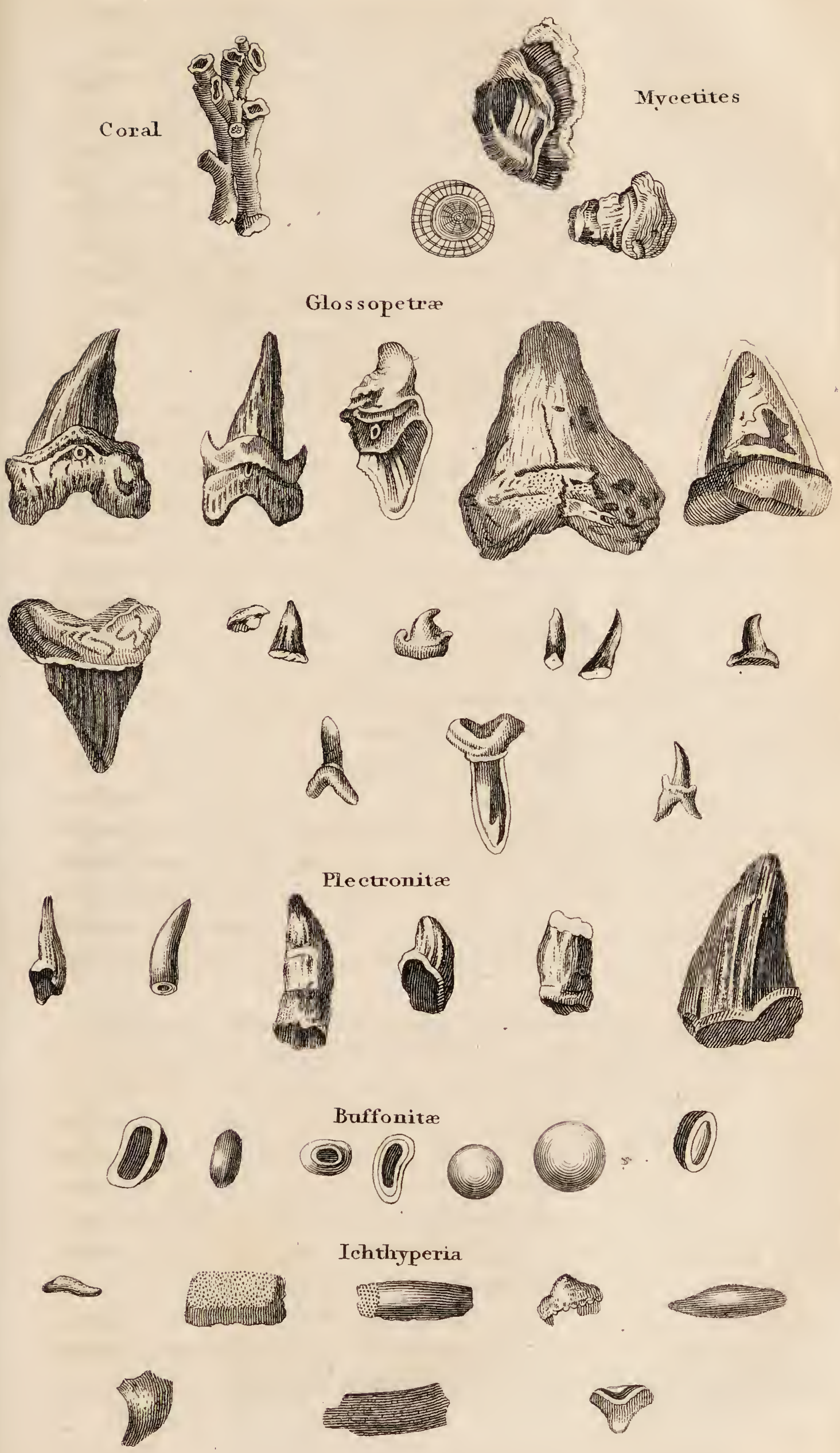
In some cases the wood is petrified with calcedony, and in others with jasper; the first has usually a yellowish white colour, and resembles decayed wood, while the latter exhibits great variety of colours. In some rare varieties of heliotrope a fibrous and probably vegetable structure occurs.

The remains of quadrupeds, birds, and amphibious animals, are seldom impregnated with mineral matter, and when this takes place, it is generally their harder parts which are petrified. The horns of deer are sometimes impregnated with clay iron ore, and bones of quadrupeds occur penetrated with lead-glance and iron pyrites, and have superimposed crystals of the same minerals. The fossil fishes in the bituminous marl slate of Thuringia are often entirely bitumenized, and, according to Werner, the bituminous impregnation of the slate is derived from these fishes. Sometimes the fishes in the marl slate are also impregnated with copper pyrites, and also with lead-glance and iron pyrites. Crustaceous animals are petrified with calcareous spar, or with iron pyrites. The Echini, or Sea Urchins, are petrified with calcareous spar, with flint, and seldom with iron pyrites. The various tribes of shells and corals are often petrified with calcareous spar, less frequently with clay iron ore, and rarely with flint or calcedony, and with sulphur. And lastly, the Alcyonia and Sponges, the lowest of the animal world met with in a fossil state, are usually penetrated or impregnated with flint.

Fossil remains of fishes occur in considerable abundance in formations of particular descriptions, but hitherto, owing to the difficulties attending the investigation, the determination of the genera and species has been far from satisfactory. Even the attempts that have been made to divide these fossil fishes into fresh and salt water species have failed. The fish, in some specimens, are found entire, with the soft parts, and even the scales, preserved by mineralization. In others, all the parts are removed, except the skeleton, and this is more or less perfect, and frequently only the hardest parts remain, such as the palates and teeth.

NATURE DISPLAYED.

Corals and Fishes Teeth.



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In Switzerland, Asia, and Africa, travellers have observed petrified fish in many places; for instance, on the mountains of Castravan, there is a bed of white laminated stone, and each lamina contains a great number and diversity of fishes; they are for the most part very flat, and extremely compressed, in the manner of fossil fern, yet, they are so well preserved, that the minutest marks of their fins and scales are distinguishable, and every other part, whereby one species of fish is known from another. There are likewise many *echinites* and petrified fish between Iver and Cairo, and on all the hills and heights of Barbary, most of which correspond with the like species taken from the Red Sea.

The description of fossil crustacea presents more difficulties than might at first be imagined. The greater number of them are in such a state of mutilation, or so enclosed in the rock, that very often there is nothing to be seen but a part of the upper surface of the body, or of the thorax; while the under surface, composed of the numerous pieces of the plastron, or sternum, giving attachment to feet composed of many articulations, and presenting also the external parts of the mouth, is found completely fixed in the substances which enclose it. The antennæ and feet, besides, are most commonly broken and separated from the body; which may be readily conceived, when we recollect with what facility these latter parts are detached from living crustacea, which lose them when fighting with one another, or even when executing some violent motions.

Fossil shells are amongst the most abundant of the organic remains met with in the strata of which our globe is composed. They exhibit not only great variety in form, but also in magnitude, having a range from the colossal ammonite, several feet in diameter, to the microscopic nautili, and other shells of the same description. They are divided into *univalve,* or those composed of one valve or piece; *bivalve,* with two valves; and *multivalve,* with more than two valves.

Univalve Fossil Shells are again divided into those with one chamber, termed *unilocular,* as the common patalla or limpet; and those with several chambers, named *multilocular*, as the nautilus. Upwards of 70 genera of unilocular shells occur in a fossil state, and many of these include numerous species. The multilocular genera are not so numerous, their number amounting to about 22, but their internal structure is so interesting as to merit notice. (*See the Engraving.*)

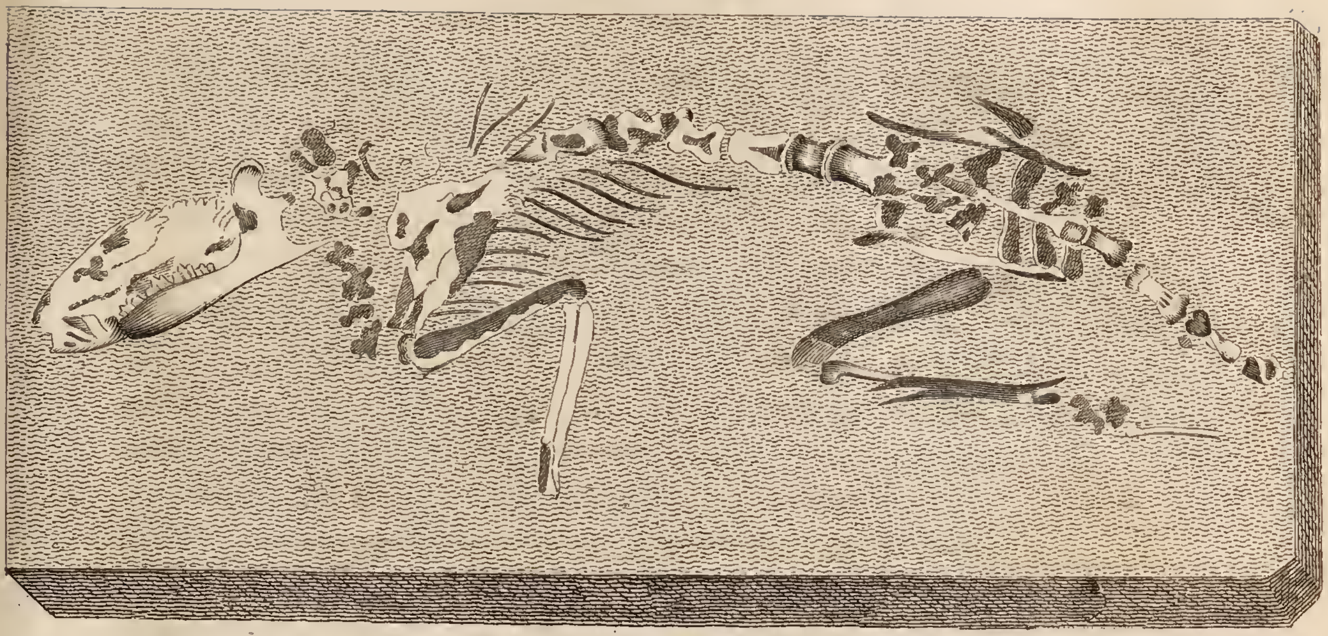
From their perishable nature, insects rarely occur in a fossil state; and when they do appear, they are generally very imperfect. Supposed larvæ of the genera *Libellula* and *Ephemera* occur in the marl slate of Œningen and Pappenheim; and the elytra of coleopterous insects in the Stonesfield slate. Insects well preserved, and of extinct species, occur in amber. Schweigger describes a piece of amber containing a perfect scorpion, but different from the common species of that genus. The ants enclosed in amber appear to be the same with the present species; so that we have the same arrangement in this substance as in rock formations, viz. known and unknown species together.

Casts and Impressions of Trees and Ferns, and other vegetable remains, occur in great abundance, and in considerable variety, in different formations, particularly in the coal formation. In some coal mines they appear well preserved, and thus afford many facilities for the determination of their characters; whilst in others, they are so much changed, as to render it nearly impossible to make out the classes and orders to which they belong.

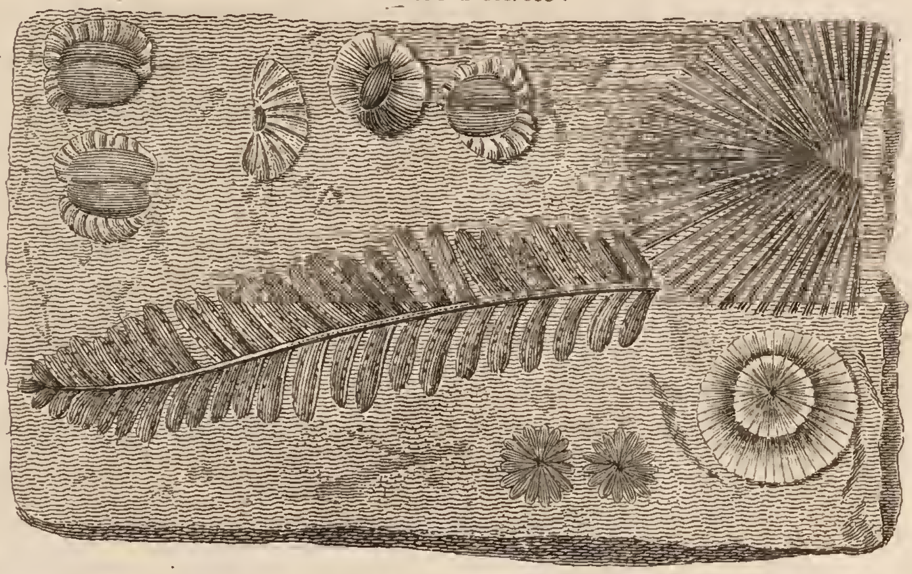
The vegetable fossils, in the Engraving, represent a curious example that was found in the mines of St. Etienne, in France, containing a fruit resembling that of coffee; a portion of an unknown vegetable, apparently of the verticillate tribe; a species of fern, which is very remarkable, as it is furnished with fructifications; part of a plant with verticillate leaves, probably a species of gallium; and some exotic fruit.

The coal formation is very remarkable on account of the numerous fossil remains of plants which it affords. Several of the principal kinds are represented in the plates annexed to this article. All the species, and most of the genera, belong to plants different from those of the present creation; many of them, and those the predominating ones, resemble cacti, palms, reeds, and ferns; intimating the general state of the earth's surface in the remote ages when they flourished.

Fossal Animal.



Fossal Plants.



Fossal Marble.

Fossil remains of birds are of rare occurrence, and the few specimens hitherto found afford results much less satisfactory than those obtained by the study of the fossil bones of quadrupeds.

The remains of the human species do not occur in the secondary strata; but the following facts prove their occurrence in fissures of rocks and in post-diluvial strata. Human bones, and even whole skeletons, have been found in clay in fissures of rocks, being the remains of bodies that had fallen into them; in other cases, human bones and skeletons have been met with, and occasionally more or less mineralized, in old deserted galleries in mines. Some years ago, human skeletons were discovered in a compact calcareous rock in the Island of Guadaloupe. A mass of this rock, enclosing a well-preserved human skeleton, but without the head, is deposited in the British Museum. The rock, on examination, proved to be a mere alluvial mass, formed of pieces of coral, that appear to have been thrown up by the sea, and afterwards united together by water impregnated with calcareous matter.

It will be interesting to exhibit, in one point of view, a few of the most remarkable facts which have been given to the world, relative to the discovery of these remains. Xenophanes of Colophon described the remains of fossil fishes found in the stone quarries of Syracuse, and in the deep marble rocks of Paros. In the 5th century before Christ, Herodotus mentions fossil shells as occurring in the rocks of Egypt, and states the fact as a proof that that country had been formerly an arm of the sea, like the Red Sea. We also find allusions to fossil organic remains in the poets of antiquity.

In Holland sea shells are found 100 feet below the surface, and in the Alps and Pyrenees they are found under beds of stone, 1000 feet. They are also found in the mountains of Spain, France, England, and in all the marine quarries of Flanders; by shells we mean not only the testaceous, but the relics of the crustaceous fishes also, and all other marine productions; and we can venture to assert, that in the generality of marbles, there is so great a quantity of marine productions, that they appear to surpass in bulk the matter whereby they are united. *(See the Slab of Super Marble in the Engraving.)*

The Isle of Cherea, in Dalmatia, contains caverns, in which are found prodigious quantities of fossil bones of oxen, horses, and sheep; similar examples occur in many places; fossil shells are found on the Alps, on the tops of mountains, on the Apennines of Genoa, in most of the quarries of stone and marble in Italy; in most parts of Germany, and in Hungary; and they are also found in the stones, whereof the most ancient edifices of the Romans were constructed.

Amongst the many instances of the multiplicity of oysters, there are few more extraordinary than that immense bed which M. De Reaumur gives an account of, which contains 130,630,000 cubic fathoms; this vast mass of marine bodies is in Touraine, in France, at upwards of 36 leagues from the sea; among them are blended some fragments of the stronger parts of sea plants, such as madrepores, fungi, marini, &c. The canton of Touraine contains full nine square leagues in surface, and furnishes these shells in every part.

The bivalve fossil shells are numerous and varied in their forms. The multivalves are of comparatively rare occurrence.

Many rocks of Spain seem almost composed of river and sea-shells, with mixed bodies beneath other rocks, in beds of blackish earth. Cornuæ ammonis, natives of deep oceans, have been discovered in very high mountains. Near Bezieres, large beds of oysters lie on the calcareous strata; and near Aix, marine petrifactions have been discovered in the heart of a marble quarry. Large masses of sea-shells have been found on the surface of plains in several parts of Asia. Among the rocks between the Zend and Orange rivers, near the Cape of Good Hope, petrifactions of shells are seen, some in situations 150 feet above the level of the sea.

The *Echinius*, or *Sea Urchin Family* exhibits great variety in form, and although not met with in the older secondary rocks, is abundant in several of the newer. Some of the species resemble those at present met with in our seas, but none of them, as far as we know, are identical with the recent ones.

NATURE DISPLAYED.

Fossils, Shells &c.

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The animals of the *Crinoidea,* or *Encrinite Family,* appear, from their internal structure and external form, to belong to a series allied to the Radiaria, and therefore cannot be arranged with the simple class of polypi. They abound in many strata, and in vast abundance, but very rarely in a living state,—a fact which shows the great difference between the animal world of the former and present period.

A complete skeleton of the colossal species of *Megatherium,* or *Sloth,* was found in diluvial soil, near Buenos Ayres, and sent to Madrid; afterwards another was discovered near Lima, and a third in Paraguay*. (See *the Engraving.*) The splendid specimen in Madrid is 14 feet long, and 7 Spanish feet in height. The skeleton of this megatherium is so rude and unshapely, that the clumsy skeleton of the elephant and rhinoceros, and even the massive and rugged bones of the hippopotamus, appear, when placed beside it, slender and light. It is one of the largest and most massive of all the fossil quadrupeds hitherto discovered.

Fossil teeth of a species of horse are found in diluvial soil, associated with those of the elephant, rhinoceros, hyæna, mastodon, and tiger. These teeth are larger than those of the present horse, and, to all appearance, belong to a different species, which inhabited the countries where they are now found, as Great Britain, along with elephants, rhinoceroses, hyænas, bears, wolves, &c.

Four species of the *Bos,* or *Ox* genus occur in a fossil state. 1. *Bos aurochs* or *urus.*—This species is considered as distinct from the common ox, being much larger. The horns and bones are found in this country, and also on the Continent of Europe. It occurs likewise in alluvial soil in the district of Ohio, in North America. 2. *Common Ox.*—The fossil skulls of this species differ from those of the present existing races in being larger, and the horns having a different direction. They are considered as belonging to the original race of the present domestic ox. The remains are of frequent occurrence in our peat-bogs, also in a similar

* Remains of the Megatherium have also been lately found in limestone caves in Brazil.

situation in Ireland. 3. *Large Buffalo of Siberia.*—Skulls and bones of a large species of ox are found in Siberia, which Cuvier maintains to be different from any of the present species; and as it occurs in the same situation as the elephant and rhinoceros of Siberia, he considers it to have lived at the same early period. 4. *Fossil Ox, resembling the Musk Ox of North America.*—The bones of this species resemble in many points those of the musk ox, but the marks of difference are so considerable as to show that it is distinct species.

Horns and skulls of a deer, nearly agreeing with the common red deer, are occasionally met with in various strata. Some of these have been found in the newer secondary formations, in supposed ancient volcanic tufas, and in diluvial strata, with remains of the elephant, rhinoceros, &c. and, lastly, in our common peat-mosses. The horns and crania found in our peat-bogs are of the same species with our present red deer, but it is not equally certain that those found in the older formations are of the same description.—Bones of a species of the roe deer are met with in our peat-mosses, and in beds of shell marl, but never in any of the diluvial strata. A species of the *Fossil Roe of Orleans*, nearly allied to the roe, but different as a species, occurs near Orleans, in France. A species of fossil fallow deer is found in peat-bogs, and in marl pits, in Scotland, England, and in different parts on the Continent of Europe. The antlers are in general larger than those of the present varieties.

A species of *Fossil Deer of Etampes* appears allied to the rein deer, but much smaller, not exceeding the roe in size. A gigantic and magnificent species of the *Cervus giganteus, Irish Elk, or Elk of the Isle of Man,* now apparently extinct, occurs in a fossil state, in Ireland, Isle of Man, England, Germany, and France. The most perfect specimen of the skeleton of this species hitherto met with, is that which was found in the Isle of Man, and now preserved in the Museum of the University of Edinburgh. It is 6 feet high, 9 feet long, and in height to the tip of the right horn, 9 feet 7 and a half inches. It was imbedded in a loose shell marl, in which were numerous imbedded branches and

Sup. Ency. Brit.

MEGATHERIUM OR SLOTH.

roots. Over the marl was a bed of sand, above the sand a bed of peat, principally composed of small branches and rotten leaves, and over the peat, the common soil of the country.

Enormous stags' horns have been dug up in different parts of Ireland. Their dimensions were as follows:

	Feet.	In.
From the extreme tip of each horn	10	10
From the tip of the right horn to its root	5	2
From the tip of one of the inner branches to the tip of the opposite branch	3	7½
The length of one of the palms, within the branches	2	6
The breadth of the same palm, within the branches	1	10½
The length of the right brow antler	1	2

A similar pair was found 10 feet under ground, in the county of Clare. At Ballyward, near Dublin; and at Portumery, near the Shannon, similar horns have been found; and the observations of several other persons, prove the great frequency with which these remains have been found in Ireland.

Two living species of *Elephant*, the Asiatic and African, and one fossil species, named *Mammoth* by the Russians, are known to naturalists. The fossil elephant or mammoth widely differs from the living species. There are in the Ashmolean Museum at Oxford, some vertebræ and leg bones of an elephant of vast size, probably 16 feet high, found in gravel near Abingdon. Mixed with these were bones of the rhinoceros, hippopotamus, horse, dog, ox, and deer.

Targioni calculates the elephants' bones that had been dug up near the Arno in Italy, in his time, equal to those of 20 individuals; and this number has been so much augmented by subsequent discoveries, that the district may be considered as a vast cemetery of these gigantic animals. It was ascertained that, before the peasants of the neighbourhood thought of preserving these bones for the sake of selling them to the curious, some of them had been in the habit of surrounding their gardens with palisades of the tibiæ and thigh-bones of the elephant. One of the persons who are in the habit of searching for these bones, ascended the hill of Poggio Rosso, where, after having removed the earth in 4 or 5 places, he found a large elephant's tusk: from thence he went to the Colle degli Stecconi, and with the same facility he dug up a large grinder, with some of the bones of the cranium, and 2 tusks—1 of which was nearly 5 feet long, and 8 inches in its greatest diameter. In Valdarno Superiore, they also find bones of the rhinoceros, the hippopotamus, stag's horns, jaw-bones and teeth of the mastodonton, and other herbivorous animals, which seem to belong to the horse and the ox.

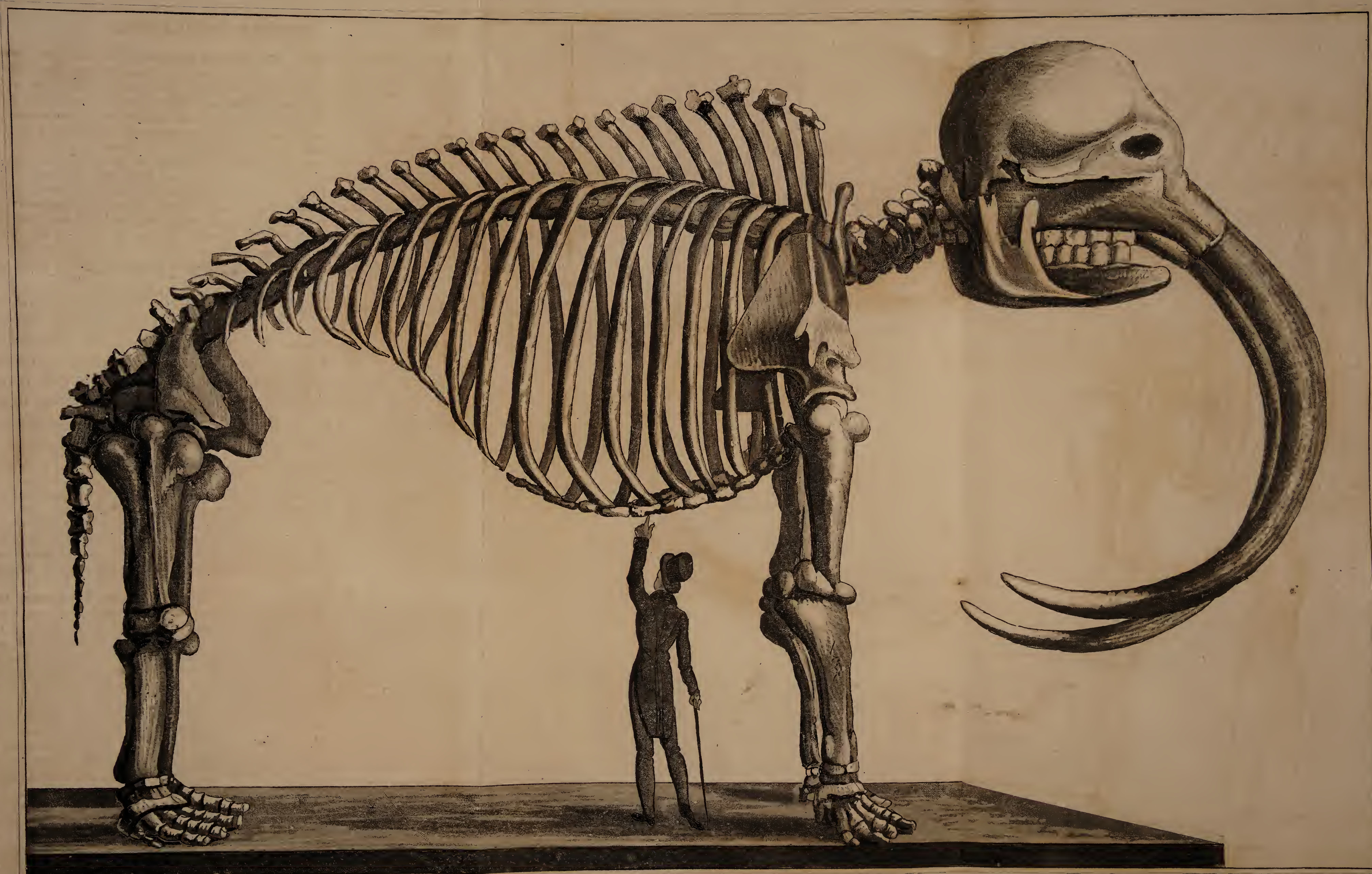
These remains are not confined to the Arno nor to Tuscany, but are found in different places on both sides of the Apennines, from

Lombardy to Calabria. M. Brocchi gives a list of the most remarkable places where they have been found, distinguishing the different species of animals. He enumerates 46 specimens of the bones of elephants, found in different situations.—There was found, in the neighbourhood of Rome, the entire skeleton of an elephant; 15 specimens of the mastodonton were found in different parts of Piedmont and Lombardy, and on both sides of the Apennines. At Castell' Arquato, there was found the greater part of the skeleton of a rhinoceros; and in Valdarno Superiore, and the territory of Perugia, different bones of the same animal. In Valdarno Superiore, in Piedmont, and in the neighbourhood of Verona, remains of the hippopotamus have been dug up; and many specimens of the head and horns of the urus have been found in the territories of Verona, Pavia, Sienna, in the Marca di Ancona, and near Rome. A head of the Irish elk was found in Oltrepò Pavese, another in the vicinity of Voghera, and a third near Lodi Vecchio.

Pallas says, that from the Don to the Tchutskoiness, there is scarcely a river that does not afford the remains of the mammoth, and that they are frequently imbedded in *alluvial soil, containing marine productions.* The skeletons are seldom complete ; but in one instance, this animal was found in an entire state, at the mouth of a river in Siberia, and a drawing made, of which we have introduced a copy.

Cuvier has demonstrated that the Siberian Mammoth is of a different species from the mastodon, or American mammoth. Its bones have been found in the alluvial soil near London, Northampton, Gloucester, Harwich, Norwich, in Salisbury plain, and in other places in England; they also occur in the north of Ireland; and in Sweden, Iceland, Russia, Poland, Germany, France, Holland, and Hungary, the bones and teeth have been met with in abundance. Its teeth have also been found in North and South America, and abundantly in Asiatic Russia.

In regard to the complete specimen which follows, it appears, that in the year 1799 a Tungusian fisherman observed a strange shapeless mass projecting from an ice-bank near the mouth of a river in the north of Siberia. He next year observed the same object, which was then rather more disengaged from among the ice, but was still unable to conceive what it was. Towards the end of the next summer, he perceived it was the frozen carcass of an enormous animal, the entire flanks of which, and one of its tusks, had become disengaged from the ice. In 1803, owing to the ice melting, this carcass became disengaged, and fell down on a sand bank. Two years afterwards, this animal still remained where it had fallen; but its body was greatly mutilated. The peasants had taken away quantities of its flesh to feed their dogs: and wild animals, particularly white bears, had also feasted on its carcass; yet the entire skeleton remained, except that one of the fore legs was gone. The entire spine, the pelvis, one shoulder blade, and three legs, were still held together by the ligaments and by remains of the skin, and the other shoulder blade was found near. The head, covered by the dried skin, remained, and the pupil of the eyes was still distinguishable. The brain, though much dried and shrunk, remained within the skull, and one of the ears was in excellent preservation, still retaining a tuft of strong bristly hair.

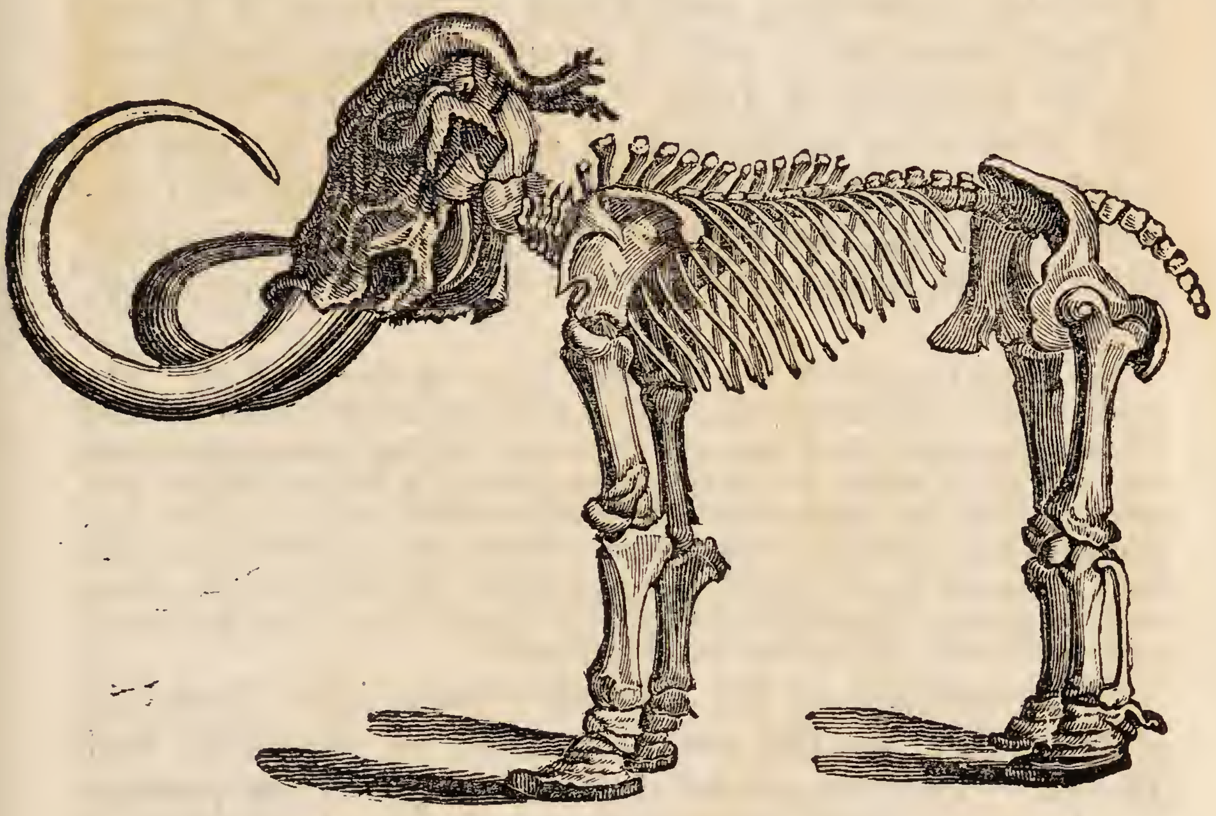


W. Read Sculp.

Skeleton of the Young Mammouth
in the Museum at Philadelphia.

The upper lip was much eaten away, and the under lip entirely gone, so that the teeth were visible. The animal was a male, and had a long mane on its back.

The skin was extremely thick, and as much of it remained as required ten men to carry away with great difficulty; more than 30lbs. of its hair and bristles were gathered, which were more than a foot in length, mixed with thinner bristles of coarse flexible hair, and wool of a reddish brown colour. It is evident that this enormous animal belonged to a race of elephants inhabiting a cold region, and that it must have been frozen up at the moment of its death.



In 1817, Dr. Mitchell, of New-York, announced the discovery of the remains of a mammoth, on the preceding day, in the town of Goshen, Orange county, within 60 miles of New-York, in a meadow of vegetable mould, which abounds with pine knots and trunks, and was, 30 years before, covered with a grove of white pine-trees. The depth below the surface, was 6 feet. These remains were subsequently put together in the Museum at Philadelphia, and we have introduced an engraving of this wonderful specimen, as drawn and published in the recent Travels of M. Montulé.

The *Mastodon of the Ohio,* appears to have been as tall as the elephant, but with longer and thicker limbs; probably it was provided with a proboscis or trunk, and had tusks like those of the elephant. It appears to have lived on roots and fleshy parts of plants, and hence this kind of food attracted it to soft and marshy places, where its fossil remains are principally found. It is more common in North America than in any other part of the world, although its remains have also been found in Siberia. The *Mastodon with Narrow Grinders,* is found in Europe, and also in North America. Besides the great mastodon and the species with narrow grinders, remains of 4 others have been met with.

Bones and teeth of the common hog occur in peat-mosses, and similar remains of a dubious species of hog in loam, along with remains of the elephant and rhinoceros. Mr. Parkinson says that 2 teeth of the narwal, or Monodon monoceros, were found on the coast of Essex, in the London clay, and that one specimen was found in the limestone of Bath. Fossil remains of dolphins and whales are mentioned as occurring in the new secondary formations of Italy; and a skeleton of the common whale was lately found near Airthry, in Stirlingshire. The skeleton of a whale was found in Scotland, in 1819.

The animal appeared to have been about 72 feet in length. The greater part of the bones were found at the depth of about 4 feet and a half; the tail lay in a westerly direction. It has been ascertained, that the place where the skeleton was found, is 20 feet higher than the surface of the highest tide of the river Forth, at the present day, and as in all the alluvial land which stretches along the river Forth, beds of sea-shells are found, it appears that the waters of the ocean must, at a remote period of time, have extended over all the flat lands, both to the west and east of Stirling Castle.

Two species of the crocodile have been found in a blue clay in the neighbourhood of Honfleur and Havre. They cannot be referred to any of the present species. In England, one specimen was obtained from the Purbeck stone, and another was found in Oxfordshire. Vertebræ are found in clay near Weymouth, and in chalk in Sussex. In the neighbourhood of Bath, the cliffs on the Dorsetshire, and on the Yorkshire coast, remains of the animals of this tribe have been often found. The matrix in which they are found is in general similar to that which has been already mentioned as containing the fossils of Honfleur and Havre,—a blue limestone, becoming almost black when wetted. This description exactly agrees with the limestone of Charmouth, Lyme, &c. in Dorsetshire; on the opposite coast to that of France, on which Havre and Honfleur are situated.

The large animal whose fossil remains are found in *the quarries of Maestricht*, has been a frequent object of admiration; and the beautiful appearance which its remains possess, in consequence of their excellent preservation, in a matrix which admits of their fair display, has occasioned every specimen to be highly valued. The length of the cervical, dorsal, and lumbar vertebræ, appears to have been about 9 feet 5 inches, and that of the vertebræ of the tail about 10 feet: adding to which the length of the head, which may be reckoned, considering the loss of the intermaxillary bones, at least at 4 feet, we may safely conclude the whole length of the skeleton of the animal to have approached to 24 feet. The head is a sixth of the animal; a proportion approaching very near to that of the crocodile, but differing much from that of the monitor, the head of which animal forms hardly a twelfth part of the whole length. There can be no doubt of its having been an inhabitant of the ocean.

Fossil remains of an animal of the same kind, found in Bavaria, are described by Sömmering, under the name *Lacerta gigantea.* "When it is considered," says he, "that this gigantic lizard was 24 feet long, we are forcibly reminded of the dragons so much spoken of in fable. At least, the fact that, at one period of the world, there existed animals of the lacerta, or dragon tribe, more than 20 feet in length, is more astonishing than all that is recorded in ancient tradition respecting monsters, which even the wildest fancy did not amplify to such enormous dimensions."

The *Megalosaurus* is a species nearly allied to the monitor in the mode of its dentition. It is found in the calcareous slate of Stonesfield, in England. The animal must, in some instances, have attained the length of 40 feet, and stood 8 feet high. The gigantic lizard of Sömmering appears diminutive when contrasted with this stupendous being.

Fossil remains of a species of canis, resembling the *dog*, and of another nearly allied to the *common fox*, and bones of the *common wolf*, have been found in post-diluvial, and diluvial soils, and in caves in England, Germany, and France.

Upwards of an hundred years ago, there were found in England, near to Dudley, in beds of limestone, organic bodies of a very singular form, and different from all the petrifactions which had been previously seen, as well as from every organized body known to exist at the surface of the earth. There was no hesitation, however, in referring them to the animal kingdom; but for a long time it could not be determined to what class they belonged; and Linnæus himself, on placing them with the insects, found their form to be so very different from that of the animals of this class, that he gave to the particular species which he has described the name of *Entomolithus paradoxus.*

But the most interesting geological discovery of modern times, is that of a stupendous cave at Kirkdale, in Yorkshire, thus described by Professor Buckland:

It was not till the summer of 1821 that the existence of any animal remains, or of the cavern containing them, had been suspected. At this time, in continuing the operations of a large quarry, the workmen accidentally intersected the mouth of a long hole or cavern, closed externally with rubbish, and overgrown with grass and bushes. In the interior of the cave there was not a single rolled pebble, nor one bone, or fragment of bone, that bore the slightest mark of having been rolled by the action of water. The cave is about 15 or 20 feet below the incumbent field, the surface of which is nearly level, and parallel to the stratification of the limestone, and to the bottom of the cave. Its main direction is ESE. but deviating from a straight line by several zigzags to the right and left; its greatest length is from 150 to 200 feet. The half corroded fragments of corals, of spines of echini and other organic remains, and the curious ledges of limestone and nodules of chert that project along the sides and roof of the cave, together with the small grooves and pits that cover great part of its interior, show that there was a time when its dimensions were less than at present. Both the roof and floor, for many yards from the entrance, are composed of horizontal strata of limestone, uninterrupted by the slightest appearance of fissure, fracture, or stony rubbish of any kind; but further in, the roof and sides become irregularly arched, presenting a very rugged and grotesque appearance, and being studded with pendent and roundish masses of chert and stalactite; the bottom of the cavern is visible only near the entrance; and its irregularities, though apparently not great, have been filled up throughout to a level surface, by the introduction of a bed of mud or sediment.

On entering the cave at Kirkdale, the first thing observed is a sediment of mud, covering entirely its whole bottom to the average depth of about a foot, and entirely covering and concealing the subjacent rock, or actual floor of the cavern. Above this mud, on advancing some way into the cave, the roof and sides are seen to be partially studded and cased over with a coating of stalactite, which is most abundant in those parts where the transverse fissures occur, but in small quantity where the rock is compact and devoid of fissures.

The bottom of the cave, on first removing the mud, was found to be strewed all over like a dog kennel, with hundreds of teeth and bones, or broken and splintered fragments of bones, of animals; they were found in greatest quantity near its mouth, simply because its area in this part was most capacious; those of the larger animals, elephant, rhinoceros, &c. were found co-extensively with all the rest, even in the inmost and smallest recesses. Fragments of jaw bones were by no means common: the greatest number seen belonged to the deer, hyæna, and water-rat, and they retained their teeth.

The effect of the mud in preserving the bones from decomposition has been very remarkable; some that had lain a long time before its introduction were in various stages of decomposition; but even in these, the further progress of decay appears to have been arrested by it; and in the greater number, little or no destruction of their form, and scarcely any of their substance, has taken place*.

It appears that the teeth and bones which have as yet been discovered in the cave at Kirkdale, are referable to the following 22 species of animals.

7 Carnivora.—Hyæna, tiger, bear, wolf, fox, weasel, and an unknown animal of the size of a wolf.

4 Pachydermata.—Elephant, rhinoceros, hippopotamus, and horse.

4 Ruminantia.—Ox, and three species of deer.

3 Rodentia.—Rabbit, water-rat, and mouse.

4 Birds.—Raven, pigeon, lark, and a small species of duck, resembling the anas sponsor, or summer duck.

Besides the teeth and bones, the cave contained also remains of horns of at least two species of deer. One of these resembled the horn of the common stag or red deer, the circumference of the base measuring 9¾ inches, which is precisely the size of our largest stag. A second measured 7¾ inches at the same part, and both had two antlers, that rose very near the base. In a smaller species, the lowest antler was 3½ inches above the base, the circumference of which was 8 inches.

It must already appear probable, from the facts above described, that the cave at Kirkdale was, during a long succession of years, inhabited as a den by hyænas, and that they dragged into its recesses the other animal bodies whose remains are found mixed indiscriminately with their own. To animals of such a class, the cave at Kirkdale would afford a most convenient habitation, and the circumstances we find developed in it are entirely consistent with the habits above enumerated.

It appears, from the researches of M. Cuvier, that the fossil hyæna was nearly one-third larger than the largest of the modern species; that is, the striped, or Abyssinian; but in the structure of its teeth, more nearly resembled that of the Cape animal. Its muzzle also was shorter and stronger than in either of them, and consequently its bite more powerful.

The fossil species has been found on the Continent in situations of two kinds, both of them consistent with the circumstances under which it occurs in Yorkshire, and, on comparing the jaws and teeth of the latter with those of the former, engraved in M. Cuvier's *Recherches*, they

* Analogous cases of the preservative powers of diluvial mud occur on the coast of Essex, near Walton, and at Lawford, near Rugby, in Warwickshire. Here the bones of the same species of elephant, rhinoceros, and other diluvial animals occur in a state of freshness and freedom from decay, nearly equal to those in the cave at Kirkdale, and this from the same cause, viz. their having been protected from the access of atmospheric air, or the percolation of water, by the argillaceous matrix in which they have been imbedded; while similar bones that have lain the same length of time in diluvial sand, or gravel, and been subject to the constant percolation of water, have lost their compactness and strength, and great part of their gelatine, and are often ready to fall to pieces on the slightest touch; and this where beds of clay and gravel occur alternating in the same quarry, as at Lawford.

are found to be absolutely identical. The two situations are caverns and diluvian gravel.

1. In Franconia, a few bones of hyænas were found mixed with those of an enormous number of bears, in the cave of Gaylenreuth.

2. At Muggendorf, in a similar cave.

3. At Bauman, in ditto.

4. At Fouvent, near Gray, in the department of Doubes, bones of hyæna were found mixed with those of the elephant and horse in a fissure of limestone rock, which, like that at Kirkdale, was discovered by the accidental digging away of the rock in a garden.

5. At Canstadt, in the valley of the Necker, A.D. 1700, hyænas' bones were found mixed with those of the elephant, rhinoceros, and horse, and with rolled pebbles, in a mass of yellowish clay.

6. Between Hahldorf and Reiterbuck, on the surface of the hills that bound the valley of Eichstadt, in Bavaria. These were buried in a bed of sand.

In Germany and Hungary are caverns containing fossil bones. Among the most remarkable are those of Gaylenreuth. Immediately beyond the opening is a magnificent grotto, of about three hundred feet in circumference, which has been naturally divided by the form of the roof into four caves. The floor is also covered with a wet and slippery glazing, in which several teeth and jaws appear to have been fixed. From this grotto commences the descent to the inferior caverns; the sides, roof, and floor, displaying the remains of animals. The rock itself is thickly beset with teeth and bones, and the floor is covered with a loose earth, the evident result of animal decomposition, and in which numerous bones are imbedded. A gradual descent leads to another grotto, which is forty feet in length, and twenty feet in height. Here the bones are dispersed about; and the floor, which is formed of animal earth, has great numbers of them imbedded in it. The bones which are here found seem to be of different animals; but in this, as well as in the former caverns, perfect and unbroken bones are very seldom found. A narrow and most difficult passage, twenty feet in length, leads from this cavern to another, five and twenty feet in height, which is every where beset with teeth, bones, and stalactitic projections. This cavern is suddenly contracted, so as to form a vestibule six feet wide, ten long, and nine high, terminating in an opening close to the floor, only three feet wide and two high, through which it is necessary to writhe with the body on the ground. This leads into a small cave, eight feet high and wide, which is the passage into a grotto twenty-eight feet high, and about three and forty feet long and wide. Here the prodigious quantity of animal earth, the vast number of teeth, jaws, and other bones, and the heavy grouping of the stalactites, produced so dismal an appearance, as to lead Esper to speak of it as a perfect model for a temple for a god of the dead. Here hundreds of cart-loads of bony remains might be removed, pockets might be filled with fossil teeth, and animal earth was found to reach to the utmost depth to which they dug. A piece of stalactite, being here broken down, was found to contain pieces of bones within it, the remnants of which were left imbedded in the rock. There is every reason to suppose that these animal remains were dispersed through a greater part of this rock. These caverns are obviously similar to the Yorkshire cavern at Kirkdale.

A large extent of islets of moor, situated on the Lincolnshire coast, is chiefly composed of *decayed trees*. In 1796, Dr. de Serra and Sir Joseph Banks examined their nature and extent. They landed on one of the largest of these islets, when the ebbs were at the lowest, and found its exposed surface to be about ninety feet in length, and seventy-five in width. They were enabled to ascertain, that these islets consist almost entirely of roots, trunks, branches, and leaves of trees and shrubs, intermixed with leaves of aquatic plants. The remains of many of the trees were still standing on their roots; but the trunks of the greater part of them lay scattered on the ground, in every direction.

In the British Museum there are preserved thirty different species of crabs from the London clay in the Island of Sheppey. Fossil shells are numerous and well preserved, often retaining nearly the appearance of recent shells. There are but few genera of recent shells that do not occur in this formation, but the species are generally different; on the other hand, few of the extinct genera, so common in the older formations, occur in this. No multilocular or bivalves of complicated structure occur in this clay. About thirty-two genera of bivalves have been found in the more ancient strata; and only five or six new genera have been found in the London clay; but on the other hand the more ancient strata have been found to contain only twelve or fourteen genera of simple turbinated univalves, whilst the London clay and its accompanying sands and crag, have afforded thirty-two genera of turbinated shells; twenty-five of which, with about sixteen other genera not known to have existed in a mineralized state, inhabit the present waters of our globe. Petrified fishes of great beauty are sometimes met with; also crocodiles and turtles, in a more or less perfectly mineralized state. It frequently contains portions of fossil wood, and vast variety of fruit or ligneous seed-vessels. Seven hundred different seed-vessels have been collected, and few of them agree with any known kinds.

The Paris formation of rocks has been sometimes distinguished into four divisions or beds according to the kind and distribution of the organic remains it contains. The *first* or *lowest bed* includes the plastic clay, coarse limestone and inferior sandstone, in all of which the organic remains are said to be entirely *marine*. The *second bed* contains the lower siliceous limestone, and the lower gypsum and marl, both of which contain scarcely any other petrifactions than those of land and fresh water animals; and hence is called a *fresh water formation*. The *third bed* is composed of the superior marls, sands, and sandstones, and the few petrifactions it contains are of *marine shells*. Lastly, the *fourth bed* is a great *fresh water formation*.

Bogs and mosses are little more than lakes filled up with vegetable matter, usually of aquatic origin. They are to be found not only in Ireland and Scotland, but also in every northern country, more especially when thinly peopled.

Sir Hans Sloane notices a curious fact, namely, that when the turf-diggers, after having dug out the earth proper to make turf or peat, reached the bottom, so as to come to the clayey or other soil, by draining off the water, they met with the roots of fir-trees, with their stumps standing upright, and their branches spread out on every side horizontally. Recently, more than one erect wood has been found at 60 feet below the surface, in the county of Wicklow. The bogs actually supply the inhabitants with the timber of ancient forests. In Lancashire too are found regular forests, lying in rows, as if overset by winds or floods.

The Countess of Moira, in a letter published in the Archæologia, mentions that a human body was found under moss *eleven feet deep*, on the estate of her husband. The body was completely clothed in garments made of *hair;* and though *hairy* vestments evidently point to a period extremely remote, before the introduction of sheep and the use of wool, yet the body and the clothes were no way impaired.

Whether the Irish morasses were at first formed by the destruction of whole forests, or merely by the stagnation of water, in places where its current was choked up by the fall of a few trees, and by the accumulation of branches and leaves carried down from the surrounding hills, is a question. Mr. Kirwan observes, that where-ever trees are found in bogs, though the wood may be perfectly sound, the bark of the timber has uniformly disappeared, and the decomposition of this bark forms a considerable part of the nutritive substance of morasses. The timber which I have found, but in particular the oak, appears to have lain for very different periods. In general it is quite black, but I have found some in which that hue was only an inch deep, and the remainder of the brown colour usually exhibited by timber cut in our own time.

Mr. Ensor, of Ardress, says, " Do you know that the trees found in the bogs have been burned down ? There is now in my yard a fir-tree of considerable dimensions, one-third of which was burnt ; and I have had in my possession also oak-trees which were incrusted with charcoal." Some arrow-heads, wooden bowls, three sacks full of nuts, and a coat of an ancient texture and construction, were, in the year 1737, dug from under a moss fifteen feet deep in Kilkenny, all of them in a high state of preservation.

The number of sea shells found in a fossil, or in a petrified state, is so amazing, that were it not for this very circumstance, we never should have had a proper idea of the surprising quantities of those animals to which the ocean gives birth: they appear in masses like mountains, in banks of 100 and 200 leagues in length, and from 50 to 60 feet thick. Limestone, marble, chalk, marl, &c. together with various others, owe their origin to shells. Nay more, I will venture to affirm, says Buffon, that shells are the medium employed by Nature in the formation of almost all stones. Many fishes inhabit the deepest parts of the ocean, and are never thrown upon the coasts; these are termed *pelasgi.* Those thrown upon the coasts are called *littorales.* The *cornu ammonis* probably belongs to the former; for these animals, the *cornua ammonis,* are no longer found in any of our seas. Shells are sometimes found more than 1000 feet below the surface; and on the top of the mountain called *Le haut de Veron,* which is elevated more than 7000 feet above the level of the sea, fragments of petrified oysters have been found.

It appears, therefore, that the continents on which we stand, were, as we have formerly said, the bottom of the sea. The surface which we now behold, received its configuration from the currents, the movements, and the inexplicable accidents it met with in the ocean. In the internal parts of the earth, as far as the excavations made by natural causes or the industry of man, have given scope for observation, we have had striking marks exhibited, of the immense changes that have been produced by the chemical action of bodies on each other, during a course of ages preceding all human record. The loftiest mountains, which run in chains through the great continents, and are composed chiefly of *granite,* were formed previously to the existence of animals and vegetables upon the present earth. The same also, it is presumed, applies to mountains of limestone, or marble of a granular texture, and is grounded on the consideration that the remains of organized substances are never found in them. Calcareous stones, says De Saussure, are universally allowed to be productions of the sea. To prove this, the vestiges of marine animals may be demanded. But the sea does not in every part of it produce shells. Moreover, there are oftentimes local causes, such as an abundance of the acid principle, which may alter and hinder petrifaction, nay even preservation. I have observed, continues this philosopher, and with great astonishment, in the argillaceous hills of Tuscany, and above all, in the environs of Sienna, for instance, near Monte Chiaro, that the hills contiguous to each other are many of them so filled with fossil shells that the earth has absolutely been white; but, on the contrary, that the others have been without the smallest trace of a shell. In the high mountains of the Alps, the slates and calcareous stones, which appear to have been formed immediately *after* the primitive rocks, seldom or never contain vestiges of marine animals; whereas those in the flat country, or in inconsiderable mountains, always abound with them.

All strata of limestone, chalks, marbles; all gypsums, spars, alabasters, &c. are confessedly of animal origin; those of coal, and of all bituminous fossils, and the mould every where covering the surface of the earth and other substances, are supposed, as we have already seen, to have arisen entirely from the destruction of animals and vegetables. Fire, and water, have left the most indubitable marks of their respective and conjoint ravages on the earth. The former, however, has, to external appearance, worked only in some parts of the surface; while the latter, in its crystallizations, has scattered its offspring of granite almost universally. From the lowest valley whence we can descend, we find prodigious heaps of marine bodies at immense depths, either in quarries of calcareous stone, in fossils, &c. and we find them also in the towering strata of mountains; in the mid regions of continents as well as in islands; from the summits even of the Alps, to some hundreds of feet below the level of Amsterdam.

The petrifactions which are thus found in a fossil state are various. It is worth, however, observing, that those of shells are found on, or nearest to, the earth; those of fish, deeper; and those of wood, deepest. That organic substances are most commonly found in strata of marl, chalk, limestone, or clay; seldom in sandstone; still more rarely in gypsum; but, never in gneiss, granite, basaltes, or schorl; but that they sometimes occur in pyrites, and ores of iron, copper, and silver; and that they are found where their originals could not have existed. The calcareous petrifactions consist of calcareous stones, in the form of animal or vegetable substances; the former are called zoophytes; the latter phytholites. The most remarkable of the former are, first, those of the coral class, of a ramified and tubular form, as coral, madrepores, millepores, astroites. Secondly, those of the class of sea-worms, as belemnites, which are of a conic or cylindrical form; asteriæ and entrochi, which have a starry appearance. And thirdly, those of the testaceous class, as nautilites, ammonites, echini, &c.

Stony, mineral, and stalactitical concretions may be found in caverns, where, by affinity, and the different laws of attraction observable in heterogeneous bodies, the air may dispel the fluid vehicle, and thus complete the consolidation. Agglutination may also be produced from the sperm of shell fish, and sea animalculæ, which operating on certain heterogeneous bodies, will unite them into a firm mass. By this process, certain soft land, will, as we have before observed, become rock;

the induration of bones and skeletons, &c. cannot be performed in so small a period of time. These remains were certainly of the antediluvian world. Stalactitical matter, and some minerals, may be produced under human observation; but the operation of indurated chalk, flint, &c. has never been noticed in its progress, nor its induration satisfactorily accounted for.

The evidence is clear, that the sea and land change place, not only from the effects of general and stated periodic laws, but from a variety of revolutions occasioned by particular and accidental causes. Thus the surface of the earth, which we look upon as the most permanent of all things, is subjected, like the rest of nature, to perpetual vicissitudes. The Great Ruler of the universe has so ordained it, that sometimes the seasons shall be displaced, sometimes the elements shall be in discord, the sea shall pass its limits, the solid earth shall shake, mountains shall run and embrace each other, contagion shall destroy man and beast, and sterility shall desolate countries. But, these afflicting disorders are effects of causes purely natural, acting conformably to fixed laws, and determined by the established nature of things.

Nor let us conclude that destruction alone is to be observed on the surface of this earth. Many, as we have seen, have maintained the universal volcanic generation of mountains. Certain islands indisputably have been thrown up. And though we may differ from them in a general sense, we willingly concede to them particular instances. The volcanic generation of mountains is not to be doubted, any more than the granite accumulations in the ocean, which at this moment perhaps are crystallizing into what will, at some future period of the world, be Alps or Cordilleras. On the 12th of May, 1707, a new island sprung up near Saint Erini, in the Archipelago. "We observed at sun rising," says F. Bourgignon, "between the two burnt islands, a floating rock, as it were, which at first we took to be some vessel shipwrecked. It continued to increase in height and extension, from its first appearance to the 13th or 14th of June, and without any noise or disturbance. On the 10th of July, at sun set, we perceived a chain of rocks, as it were, that rose up from a prodigious depth of the sea, to the number of 17 or 18, not very distinct from each other, and apparently inclining to join themselves to the new island. The next day, smoke was observed to break forth, much resembling in thickness and colour that of a burning furnace; and at the same time were heard certain murmurings under ground, which seemed to proceed from the centre of this new island. The rocks then recently formed, united together, and seemed to form another island distinct from the former. The smoke still increased; but, on the following day, the fire broke forth, at first of a dull colour, but afterwards more vivid, as the island increased, and so continued, and from a variety of apertures. It was no less frightful than curious to the sight, to see every evening on the top of this mount, that nature had lately formed, a vast number of burning furnaces, all of a bright flame, and not unlike the illuminated minarets of the Turks. In the mean time, the burnt island increased prodigiously, and extended itself chiefly on the south and north sides; the sea also seemed much more disturbed, and was loaded with sulphur and vitriol; the boiling of the sea was more fierce and violent, the smoke became thicker and in greater abundance, and the fire larger and more frightful. But, above all, a stench, which infected the whole country, became so intolerable, that persons of the strongest constitutions could hardly breathe in it. In thirteen or fourteen days there was a considerable alteration in the size and appearance of these islands: they became considerably higher and longer, and at length absolutely joined and formed but one island, and on the 20th of November, it appeared to be at least three miles in circumference, and forty feet in height."

Creation, and destruction, thus regularly succeed to one another. Nothing is at a stand. All is in motion, and every revolution serves but to some wise purpose. Thus, while some regions are undermining, others are forming; while this mountain crumbles, its resemblance consolidates in the ocean; while flints, jaspers, petrosilex, feldspar, granites, lavas, and ferruginous stones, from long exposure to the air, fall into a state of decomposition, similar bodies and crystallizations assume their distinct shapes, and wait but to be called into being. This succession is most admirable. Every particle of matter thus comes into action. But the time required for such regeneration is infinitely, perhaps, too unbounded for the circumscribed imagination and faculties of man.

Our globe is indisputably, both internally and externally, irregular. It projects with mountains, and is wrought into caverns. Its surface is unequal, and its inner parts are variegated. The alterations it has undergone, have been manifold. To a few evident causes, however, they may in general be attributed, though they cannot in any manner be proved. First, to heat, which melts, volatilizes, mixes, combines, calcines, vitrefies, and consequently gives birth to fiery eruptions. Secondly, to water, which may be said to be the most universal, as it searches every where. Thirdly, to air, which, by its currents, forms the winds, which, pent up in caverns, and rarefied by heat, burst through every thing that opposes them; break out caverns, and open those mouths, whence issue forth inevitable destruction. And fourthly, to substances of a saline nature, which greatly assist inflammation.

The globe, at least to a certain depth, is not every where solid; but is intermixed with mighty caverns, whose arches support the incumbent earth, which in the progress of time inevitably give way. Then instantly rush in the waters, and by filling them, leave a quantity of dry land, which shortly becomes an habitation for terrestrial animals. These, in their turn, undergo a similar fate. Thus succeeds revolution to revolution.

In viewing these changes the philosopher who turns his mind to the contemplation of the general system of nature, too frequently fancies a quickness and impetus of operation, which probably bear no more analogy to the thing itself, than the energy of his own feeble powers do, to the all-actuating universal cause. Nature is slow in her operations. She proceeds by insensible gradations. Man, on the contrary, would be as momentary as his thoughts. Ages, probably, are necessary to the consolidation of metals; ages we can readily believe to be required for the formation of precious stones. But, these are all imitated by art, and are even brought to a certain degree of perfection, in very inconsiderable spaces of time. This makes us assuming: but look into yon sparry Cavern in the mountain; remark that grotesque indurated mass; it is the growth of a period so unlimited, as to afford us no room even for conjecture, as to the æra of its origin: and yet, in the chemist's laboratory, he could produce you a stone, for the formation of which, a few hours would be more than sufficient. Let us not, however, argue hence, that nature proceeds in the manner we do: it is too great a degree of rashness, to assume the extent of the power of the artist, as a limit for that of the Creator; and to imagine, that the state of our acquisitions is the state of absolute information. With sure, but gentle pace, nature pursues her ends. She composes and decomposes with measured step. We may think ourselves possessed of her secrets: the difference, however, may be as great, as an atom is to a world, or as eternity is to a moment. But the real philosopher shuns such illusory ideas. He neither demands how the world exists; attempts to penetrate the reason of its existence; the æra of its birth, or the mode of its dissolution. To him it is sufficient, if he can but trace and consider a few of its phenomena; if, in his inquiries, he can but find out a link in the chain of causes and effects; or if, in the contemplation of the mighty fabric, he can but form probable conjectures on a few of the laws by which it is regulated.

LECTURE XXX.

CAVERNS AND PETRIFACTIONS.

Give me, ye powers, the wondrous scenes to show,
Conceal'd in darkness, in the depths below.

In surveying the subterranean parts of the globe, beside the fissures that descend vertically, we frequently find openings that descend but a little way, and then spread themselves often to a great extent horizontally. A few of these caverns are the production of human art and industry, made to protect the oppressed or shelter the robber, but the greater part are works of nature, and often result from currents of rivers which formerly passed through them.

The famous labyrinths of Candia; the stone quarry of Maestricht; the salt mines in Poland; some of the catacombs in Egypt and Italy; the chalk excavation at Reigate; and a great number of artificial caverns in Spain, are human productions. But there is scarcely a country in the world without its natural caverns; and, every day, many new ones are discovered. Those in England, Oakey-hole in Somersetshire, the Devil's-hole in Derbyshire, and Penmark-hole in Gloucestershire, have been often described. But of the subterranean caverns now known, the most celebrated are the Grotto of Antiparos, the great Cavern of Kentucky, Fingal's Cave in Staffa, the Cavern of Guacharo, in South America, and that near Water Town, in North America.

The grand Staffa Cavern, or Fingal's Cave, on the small island of Staffa, in the Hebrides, is situate about seven miles N. N. E. of Iona, and equi-distant westward from the shores of Mull. It is formed by the wearing away, by the tides, of the basaltic pillars on which the island and much of the land in the vicinity is formed. These stand in natural colonnades, mostly above fifty feet high, upon a firm basis of solid unshapen rock; and above these the stratum, which reaches to the soil of the island, varies in thickness, in proportion to the distribution of the surface into hill and valley. The pillars have three, four, and more sides; but the number of those with five and six exceeds that of the others. It is supported on each side by ranges of columns, and is roofed by the bottoms of those columns which the tide has broken away. From the interstices of the roof a yellow stalactitic matter has exuded, which precisely defines the different angles; and, varying the colour, tends to augment the elegance of its appearance. The whole cave is lighted from without, in such manner, that the farthest extremity is plainly distinguished.

The following are its dimensions.	Feet.	In.
Length of the cave from the rock without	371	6
from the pitch of the arch	250	0
Breadth of ditto at the mouth	53	7
at the farther end	20	0
Height of the arch at the mouth	117	6
at the end	70	0
Height of an outside pillar	39	6
one at the north-west corner	54	0
Depth of water at the mouth	18	0
at the extremity	9	0

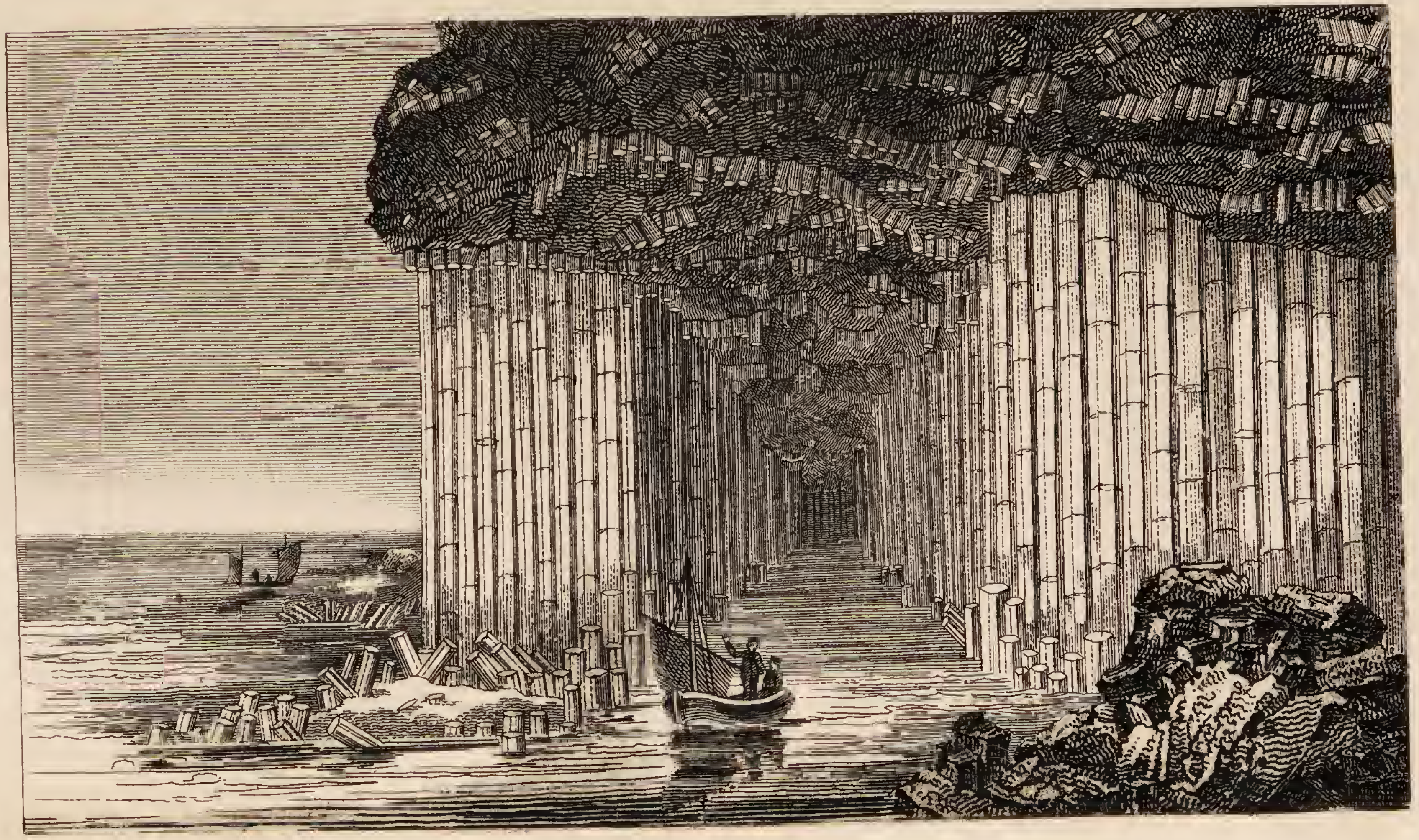
The thickness of the stratum of lava-like matter below the pillars, the height of the pillars, and the thickness of the superincumbent stratum at three different places westward of the mouth of the cave, beginning with the corner pillar of the cave, are, in feet, described as under:

	Feet.	Feet.	Feet.
Stratum below	11	17	20
Height of pillars	54	50	65
Stratum above	61	51	55

The stratum above the columns is uniformly the same, consisting of numberless small pillars, bending and inclining in all directions, sometimes so irregularly, that the stones can only be said to have an inclination to assume a columnar form; in others more regularly; but never breaking into, or disturbing the stratum of large pillars, whose tops keep every where an uniform line.

In addition to the foregoing description by Sir Joseph Banks, are the following observations by M. Saussure, in his Voyage to the Hebrides: Figure to yourself a vault 350 feet in depth, and 117 in height; supported on each side by close groups of prisms, some with six faces, others with seven or eight sides, rising vertically to a height of more than 50 feet, preserving always the most perfect regularity. On entering the cave of Fingal, we felt an indescribable impulse of admiration. The grandeur and majestic simplicity of this vast hall, the obscurity which reigns there, and which increases still more the solemnity of the basaltic pillars, the rolling waves striking against the walls, and which in breaking against the bottom of the cavern produce a noise at times similar to the rolling of distant thunder, the echoes resounding from the vault repeating and prolonging all the sounds with a kind of harmony; all these features united produce in the mind a sensation which invited us to meditation and religious awe.

Of the Grotto of Antiparos, Dr. Clarke gives the following description: "We now came to the mouth of this most prodigious cavern, which may be described as the greatest natural curiosity of its kind in the known world. As to its origin, it may possibly have been a very ancient mine, or a marble quarry, from the oblique direction of the cavity, and the parallel inclination of its sides. The mode of descent is by ropes, which on the different declivities are either held by the natives, or they are joined to a cable which is fastened at the entrance around a stalactite pillar. In this manner, we were conducted, first down one declivity, and then down another, until we entered the spacious chambres of this truly enchanted



FINGALS CAVE IN STAFFA.

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grotto. Having visited the stalactite caverns of the gulf of *Salernum* upon the coast of Italy, those of *Terni*, and many other places, the author expected to find similar here; but there is nothing which resembles this grotto. The roof, the floor, the sides of a whole series of magnificent caverns, were entirely invested with a dazzling incrustation as white as snow. Columns, some of which were five and twenty feet in length, pended in fine icicle forms above our heads: (see the engraving.) Others extended from the roof to the floor, with diameters equal to that of the mast of a first-rate ship of the line. The incrustations of the floor, caused by falling drops from the stalactites above, had grown up into dendritic and vegetable forms, which first suggested to Tournefort the strange notion of his having here discovered the vegetation of stones. The last chamber into which we descended surprised us more by the grandeur of its exhibition than any other. Probably there are many other chambers below this, yet unexplored, for no attempt has been made to penetrate farther: and, if this be true, the new caverns, when opened, would appear in perfect splendor, unsullied, in any part of them, by the smoke of torches, or by the hands of intruders.

The Great Cavern of Guacharo, in South America, is pierced in the vertical profile of a rock. The entrance is toward the south, and forms a vault eighty feet broad, and seventy-two feet high. The rock, that surmounts the grotto, is covered with trees of gigantic height. The mammee-tree, and the genipa with large and shining leaves, raise their branches vertically toward the sky; while those of the courbaril and the erythrina, form, as they extend themselves, a thick vault of verdure. But this luxury of vegetation embellishes not only the outside of the vault, it appears even in the vestibule of the grotto. Plantain-leaved heliconias eighteen feet high, the praga palm-tree, and arborescent arums, follow the banks of the river even to those subterranean places. Day-light penetrates into this region, because the grotto forms but one single channel, which keeps the same direction, from south-east to north-west. Where the light begins to fail, the hoarse sounds of the nocturnal birds are heard. The guacharo is of the size of our fowls, has the mouth of the goatsuckers and procnias, and the port of those vultures, the crooked beak of which is surrounded with stiff silky hairs. It forms a new genus, very different from the goatsucker by the force of its voice, by the considerable strength of its beak, containing a double tooth, by its feet without the membranes that unite the anterior phalanxes of the claws. In its manners it has analogies both with the goatsuckers and the alpine crow. The plumage of the guacharo is of a dark bluish-grey, mixed with small streaks and specks of black. It is difficult to form an idea of the horrible noise occasioned by thousands of these birds in the dark part of the cavern, and which can only be compared to the croaking of our crows, which, in the pine forests of the north, live in society, and construct their nests upon trees, the tops of which touch each other. Their nests are fifty or sixty feet high above our heads, in holes in the shape of funnels, with which the roof of the grotto is pierced like a sieve. The Cavern winds on the banks of the small river which issues from it, and is from 28 to 30 feet wide; this subterraneous rivulet is the origin of the river Caripe, which, at a few leagues distance, after having joined the small river of Santa Maria, is navigable for canoes. It enters into the river Areo under the name of *Canno de Terezen*. The grotto of Caripe preserves the same direction, the same breadth, and its primitive height of sixty or seventy feet, to the distance of 1458 feet, accurately measured. The superstitious natives connect mystic ideas with this cave, inhabited by nocturnal birds;

they believe, that the souls of their ancestors sojourn in the deep recesses of the cavern.

The GREAT KENTUCKY CAVERN is 10 or 12 miles in length, with many extensive branches. The surrounding country is much broken into ravines and pits, at the bottom of one of which is the entrance. Mr. N. Ward, who explored this cavern, gives the following description of it: "At eight in the morning, I started with the guides, taking with us two large lamps, a compass, and something for refreshment; and entering the cave, about 60 rods from the house, down through a pit 40 feet deep and 30 in circumference; at the bottom is a spring of water. (See the plan of this wonderful place annexed.) You are now at the entrance of the cave (A); which opens to the north, and is from 40 to 50 feet high, and about 30 in width for upwards of 40 rods, when it becomes but 10 feet wide and five feet high. However, this continues but a short distance, when it expands to 40 or 50 feet in width, and is about 20 in height for about one mile, until you come to the *First Hoppers* (B) where saltpetre is manufactured. Thence, it is about 40 feet in width and sixty in height to the *Second Hoppers* (B), two miles from the entrance. The loose limestone has been laid up into handsome walls on either side, almost the whole distance from the entrance to the *Second Hoppers:* the road is hard, and as smooth as a flag pavement. The walls of the cavern are perpendicular in every passage that I traversed; the arches are regular in every part, and have bid defiance even to earthquakes. One of my guides informed me he was at the *Second Hoppers* in 1812, with several workmen, when those heavy shocks came on, which were so severely felt in this country. He said, that about five minutes before the shock, a heavy rumbling noise was heard coming out of the cave like a mighty wind; when that ceased, the rocks cracked, and all appeared to be going in a moment to final destruction. However, no one was injured, although large rocks fell in some parts of the cave.

As you advance into the cave, the avenue leads from the *Second Hopper*, west one mile, then S. W. to the 'Chief City' (D) which is six miles from the entrance. This avenue is from 60 to 100 feet in height, and about the same in width, the whole distance after you leave the *Second Hoppers*, until you come to the cross roads or Chief City, and is nearly upon a level; the floor, or bottom, being covered with loose limestones and saltpetre earth.

After entering the Chief City, I perceived five large avenues leading out of it, from 60 to 100 feet in width, and from 40 to 80 in height. The walls (all of stone) are arched, and are from 40 to 80 feet perpendicular height before the arch commences. The first which I traversed after cutting arrows on the stones under our feet, pointing to the mouth of the cave (in fact we did this at the entrance of every avenue, that we should not be at a loss for the way out, on our return) was one that led us in a southerly direction for more than two miles. We then left it, and took another that led us east, and then north, for more than two miles further: and at last, in our windings, were brought out by another avenue into the *Chief City* again, after traversing different avenues for more than five miles. We rested ourselves for a few minutes on some limestone slabs near the centre of this gloomy area; and after having refreshed us, and trimmed our lamps, we took our departure a second time through an avenue almost north, and parallel with the avenue leading from the Chief City to the mouth of the cave, which we continued for upwards of two miles, when we entered the *Second City* (E). This is covered with one arch, nearly 200 feet high in the centre, and very similar to the *First City*, ex-

W. Daniell in Woods Zoography

GROTTO OF ANTIPAROS.

cept in the number of avenues leading from it; this having but two. We passed through it, over a very considerable rise in the centre, and descended through an avenue which bore to the east about three hundred rods, when we came upon a third area (L) about 200 feet square and 50 in height, which had a pure and delightful stream of water issuing from the side of the wall about 60 feet high, and which fell upon some broken stones and was afterwards entirely lost to our view. After passing this beautiful sheet of water a few yards, we came to the end of this passage.

We then returned about one hundred yards, and entered a small avenue (over a considerable mass of stone) to our left, which carried us south, through an uncommonly black avenue, something more than a mile, when we ascended a very steep hill about 60 yards, which carried us within the walls of the *Fourth City* (F), which is not inferior to the second, having an arch that covers at least six acres. In this last avenue, the farther end of which must be four miles from the *Chief City*, and ten from the mouth of the cave, are upwards of twenty large piles of saltpetre earth on one side of the avenue, and broken limestone heaped up, evidently the work of human hands.

I had expected, from the course of my needle, that this avenue would have carried us round to the *Chief City*, but was sadly disappointed when I found the end, a few hundred yards from the *Fourth City*, which caused us to retrace our steps; and not having been so particular in marking the entrances of the different avenues as I ought, we were very much bewildered, and once completely lost for fifteen or twenty minutes. At length, we found our way, and, weary and faint, entered the *Chief City* at ten at night. We now entered the fifth and last avenue from the *Chief City*, which carried us south-east about 900 yards, when we entered the *Fifth City* (G), whose arch covers upwards of four acres of level ground strewed with broken limestone. Fire-beds of uncommon size, with brands of cane lying around them, are interspersed throughout this city.

We crossed over to the opposite side, and entered an avenue that carried us east about 250 rods: finding nothing interesting in this passage, we turned back, and crossed a massy pile of stone in the mouth of a large avenue, which I noticed, but a few yards from this last-mentioned city, as we came out of it. After some difficulty in passing over this mass of limestone, we entered a large avenue, whose walls were the most perfect of any I saw, running almost due south for 500 rods, very level and straight, with an elegant arch. When at the end of this avenue, and while I was sketching a plan of this cave, one of my guides, who had been some time groping among the broken stone, called out, requesting me to follow him.

I gathered up my papers and compass; and after giving my guide, who sat with me, orders to remain where he was until we returned, and, moreover, to keep his lamp in good order, I followed after the first, who had entered a vertical passage just large enough to admit his body; we continued stepping from one stone to another, until at last, after much difficulty from the smallness of the passage, which is about ten feet in height, we entered on the side of a chamber at least 180 feet in circumference, and whose arch is about 150 feet high in the centre. After having marked arrows pointing downwards upon the slab-stones around the little passage through which we had ascended, we walked forward nearly to the centre of this area.

It was past midnight when I entered this chamber of eternal darkness. With the guide, I took the only avenue leading from this chamber, and traversed it to the distance of a mile in a southern direction. The avenue, or passage, was as large as any that we had entered;

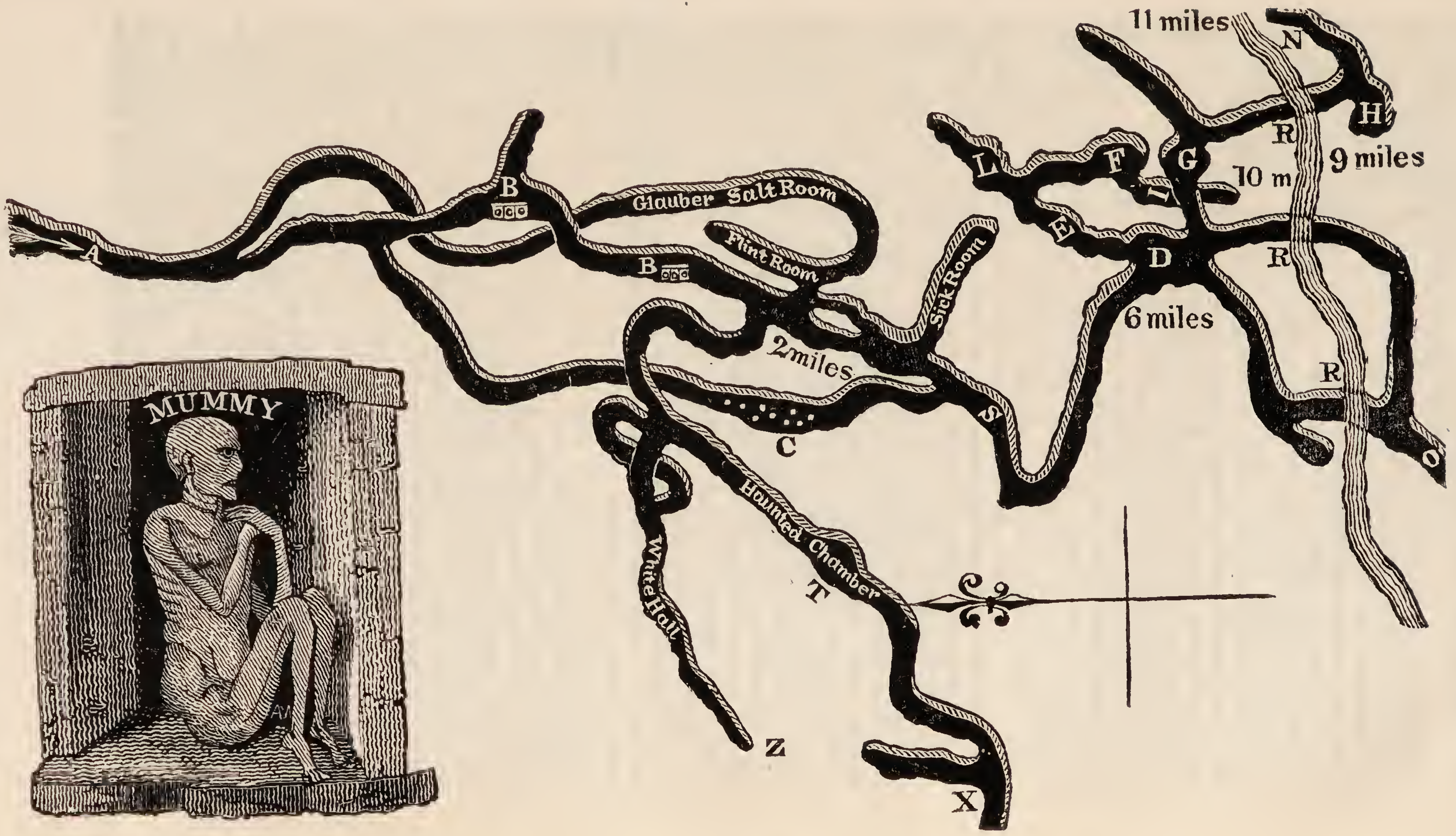
and how far we might have travelled, had our lights held out, is unknown.—It is supposed that *Green River*, a stream navigable for boats, passes over three branches of this cave (R R R).

It was nearly one o'clock when we descended 'the passage of the chimney,' as it is called, to the guide whom I had left seated on the rocks. He was quite alarmed at our long absence, and was heard by us a long time before we reached the passage to descend to him, hallooing with all his might, fearing we had lost our tract in the ruins above. Very near the vertical passage, and not far from where I left my guide sitting, I found some very beautiful specimens of soda, which I brought out with me. We returned over piles of saltpetre earth and fire-beds, out of one avenue into another, until at last, with great fatigue and a dim light, we entered the walls of the *Chief City*, where, for the last time, we trimmed our lamps, and entered the spacious avenue that carried us to the *Second Hoppers.* I found, when in the last-mentioned large avenue or upper chamber, many curiosities, such as Glauber salts, Epsom salts, flint, yellow ochre, spar of different kinds, and some petrifactions, which I brought out, together with the *Mummy*, which was found at the *Second Hoppers* (B). We happily arrived at the mouth of the cave about three in the morning, nearly exhausted with nineteen hours' continued fatigue.

There is a passage in the main avenue, about 60 rods from the entrance, like that of a trap door: by sliding aside a large flat stone, you can descend 16 or 18 feet in a very narrow defile, where the passage comes upon a level, and winds about in such a manner as to pass under the main passage without having any communication with it, and at last opens into the main cave by two large passages. It is called *Glauber Salt-room*, from salts of that kind being found there; there is also the *Sick Room*, the *Bat Room*, and the *Flint Room*, all of which are large, and some of them quite long. The last I shall mention is a very winding avenue, which branches off at the *Second Hoppers*, and runs west and south-west for more than two miles: this is called the *Haunted Chamber*, from the echo of the sound made in it. The arch of this avenue is very beautiful, incrusted with limestone, spar, and in many places the columns of *spar* are truly elegant, extending from the ceiling to the floor. I discovered in this avenue a very high dome (T), in or near the centre of the arch, apparently 50 feet high, hung in rich drapery, festooned in the most romantic manner for six or eight feet from the hanging, and in colours brilliant.

The columns of spar and the stalactites in this chamber are extremely romantic in their appearance, with the reflection of one or two lights. There is a chair formed of this spar, called *Wilkins's Arm-chair*, which is very large, and stands in the centre of the avenue, and is encircled with many smaller ones. Columns of spar fluted, and studded with knobs of spar and stalactites, drapery of various colours superbly festooned, and hung in the most graceful manner, are shown with brilliancy from the reflection of lamps.

A part of the *Haunted Chamber* is directly over the *Bat Room*, which passes under the *Haunted Chamber*, without having any connexion with it. My guide led me into a very narrow defile on the left side of this chamber, and about 100 yards from *Wilkins's Arm-chair*, over the side of a smooth limestone-rock, 10 or 12 feet, which we passed with much precaution; for had we slipped from our hold, we had gone 'to that bourne whence no traveller returns,' if I may judge from a cataract of water, whose dismal sound we heard at a considerable distance in this pit, and nearly under us. However, we crossed in safety, clinging fast to the wall, and winding down under the *Haunted Chamber*, and through a very narrow passage for



Plan of the Great Kentucky Cavern.

30 or 40 yards, when our course was west, and the passage 20 or 30 feet in width, and from 10 to 18 high, for more than a mile. At the further part of this avenue, we came upon a reservoir of water, apparently having neither inlet nor outlet (X).

We returned by the beautiful pool of water, which is called the *Pool of Clitorius.* On our way back to the narrow defile, I had some difficulty in keeping my lights, for the bats were so numerous and continually in our faces, that it was next to impossible to get along in safety. We returned by *Wilkins's Arm-chair*, and back to the *Second Hoppers.* It was at this place I found the *Mummy*, (see the engraving,) where it had been carried from another part of the cave, for preservation. It is a female, about six feet in height, and so perfectly dried as to weigh but twenty pounds when I found it. The hair on the back part of the head is rather short, and of a sandy hue; the top of the head is bald,—and the eyes sunk into the head; the nose, or that part which is cartilaginous, is dried down to the bones of the face; the lips are dried away, and discovered a fine set of teeth, white as ivory. The hands and feet are perfect, even to the nails, and very delicate like those of a young person; but the teeth are worn as much as a person's at the age of fifty. The entire Cavern has palpably been the channel of a river; the furrows worn by which are still visible on the sides and in the floor.

The STUPENDOUS CAVERN on the north bank of the Black River, opposite the village of Watertown, from the great extent of the cavern, and the great number of spacious rooms, halls, and chambers, into which it is divided, it is difficult, if not impossible, to describe. —The mouth of the cavern is in a small hollow, about five feet below the surrounding surface of the earth. The descent is by sixteen feet and a half into a room, in which is a table rock, twelve or fourteen feet square, two feet thick, and elevated about four feet from the bottom of the cavern, the roof over-head covered with stalactites, some of which reach to the table rock. On the left is an arched way of one hundred and fifty feet, and on the opposite side is another arched way, which leads into a large room. Another arch leads into a hall ten feet wide and 100 feet long, from five to eight feet high, supported with pillars and arches, and the sides bordered with curtains, plaited in variegated forms, as white as snow. Near the middle of this hall is an arched way, leading to a large room, which, like the hall, is bordered with curtains, and hung over with stalactites. The descent is by ten feet, into a chamber about twenty feet square and two feet high, hung over with stalactites. Descending from this chamber, and passing through another arch into a hall, by the side is a basin of water, rising about four inches from the floor. The number and spaciousness of the rooms, curtained and plaited with large plaits, extending along the walls from two to three feet from the roof, of the most perfect whiteness, resembling the most beautiful tapestry, with which the rooms are embroidered; and the large drops of water, which are constantly suspended on the points of innumerable stalactites, which hang from the roofs above; and the columns of spar resting on pedestals, which, in some places, appear to be formed to support the arches above—the reflection of the lights, and the great extent and variety of the scenery of this amazing cavern,—form, altogether, a sublime spectacle.

In the limestone country of Virginia, in North America, are several Caverns; among which the most celebrated is MADISON'S CAVE, on the north side of the Blue Ridge. Its entrance is about two-thirds high, in a moderately elevated hill, into which it extends about 300 feet, branching out into subordinate caverns, sometimes ascending a little, but more generally descending, and at length terminates at different places, in two basins of water, of unknown dimensions, that are never turbid. The vault of this cave is of solid limestone, from 20 to 40 or 50 feet high, through which water perpetually percolates; and trickling down its sides, has incrusted them with elegant drapery, or dripping from the top, generates conical stalactites both above and below.

In COCHIN CHINA, one most remarkable grotto traverses a mountain throughout: its entrance and its exit being terminated by two fertile plains. The bottom is covered with water, which may be navigated by vessels; and the roof, which is very lofty in some places, decreases elsewhere to 8 or 10 feet. There is another in the same chain of mountains, of vast extent, but abounding in deleterious exhalations; and the water of a canal covering its bottom is dangerous to be drank.

The GROTTO DEL CANE, beside the lake Agnano, in Italy, is of limited dimensions, being only 12 feet deep, 4 broad, and 9 in height at the entrance. The celebrity of this grotto, which has long been known, is owing to pestilential exhalations arising from the earth; and it receives its name from the animal which is usually selected to demonstrate their presence. If a dog be brought within the sphere of the deleterious vapour, which remains within 18 inches of the surface, its respiration immediately becomes affected—the abdomen contracts—the eyes are fixed—and the tongue, now of a livid hue, hangs out during the first minute, while, in the next, the animal is totally deprived of motion. Death would inevitably follow, but, on being speedily withdrawn, the lungs resume their play, and the creature gradually recovers its wonted strength and vigour; nevertheless a severe shock has been sustained, as the dog cannot support the experiment above 12 or 15 times without destruction; in which event it dies in convulsions. The Abbé Nollet, on stooping to inhale the vapour, felt as if he had swallowed boiling water on the first inspiration, yet producing no painful sensations. On lowering his face, a kind of suffocation was experienced; and, probably, had the experiment been continued longer, dangerous consequences would have ensued. The vapour is whitish, and possesses some degree of heat: it never rises above 18 inches from the earth; and a torch immersed in it is extinguished, while the black smoke rolls over its surface without penetrating deeper.

The PEAK OF DERBYSHIRE, consists of a chain of high mountains, and is celebrated for its mineral productions, natural curiosities, and wonders; which we shall briefly notice, as they are fully detailed in a popular work, entitled the Hundred Wonders of the World. Six of these are natural, namely, the Peak Cavern, or the Devil's Hole, Pool's Hole, Elden Hole, Mam Tor, St. Anne's Well, and the Ebbing and Flowing Well.

PEAK CAVERN, also called the *Devil's* Hole, lies in the vicinity of Castleton, and is approached by a path at the side of a clear rivulet, leading to the fissure, or separation of the rock, at the extremity of which is the cavern; in front, overhung by a vast canopy of rock, assuming the appearance of a depressed arch, one hundred and twenty feet wide, forty-two high, and in receding depth, about ninety. At about ninety feet, the roof becomes lower, and a gentle descent leads, by a detached rock, to the interior of this tremendous hollow. Here the light of day wholly disappears; and the visitor is provided with a torch to illume his further progress. *See the Engraving.*

He now proceeds about twenty yards, to a spacious opening, named the Bell-house, and thence to a small lake, the *First Water*, about forty feet long, and two or three deep, over which he is conveyed in a boat to the interior of the cavern, beneath a massive vault of rock, which in some parts descends almost to the water. M. de St. Fond says, "We stood some time on the brink of this lake; and the light of our dismal torches, which emitted a black smoke, reflecting our pale images from its bottom, we almost conceived we saw a troop of spectres starting from an abyss to welcome us. The illusion was extremely striking."

On landing, the visitor enters a spacious vault, 220 feet long, 200 broad, and in some parts 120 high, in the bosom of the rock; but from the want of light, neither the distant sides, nor the roof are seen. At the inner extremity, the stream spreads into the *Second Water*. Beyond which, opens another tremendous hollow, called the *Chancel*, where the rocks are much broken, and the sides covered with stalactics and petrifactions. The path now leads to a place whimsically called the *Devil's Cellar*, and *Half-way House*, and thence, by three natural and regular arches, to a vast concavity, which, from its uniform bell-like appearance, is called *Great Tom of Lincoln.*

The entire length of this wonderful cavern is 2250 feet, nearly half a mile; and its depth, from the surface of the Peak mountain, about 620 feet.

Pool's Hole, about a mile west of Buxton, is a vast natural cavern in a limestone rock, once the residence of an outlaw, named Pool. The entrance is low and contracted, and the passage narrow; but widens into a lofty, spacious cavern, from whose roof stalactites hang in spiral masses; or drop to the floor and rise in cones, termed *stalagmites.*

One immense stalactite, called the *flitch of bacon;* another, surprisingly large, is named *Mary Queen of Scots' Pillar*, that unfortunate queen having visited the cavern, and proceeded thus far into its recesses. The cavern terminates at nearly three hundred feet beyond the Queen of Scots' pillar. In one part is a fine spring of transparent water; and a small stream, more considerable in rainy seasons, runs the whole length of the cavern, which resembles the interior of a Gothic cathedral, and has a fine effect.

Elden Hole, on the side of a hill about a mile north-west of the village of Peak Forest, is a deep chasm in the ground, surrounded by a wall of uncemented stones, and the mouth opens horizontally, from north to south; its shape is that of an irregular ellipsis, about ninety feet long, and twenty-seven broad where widest. The northern end is fringed with small trees; and moss and underwood grow out of the crevices on each side, to the depth of forty or fifty feet. As the fissure recedes from the surface, it gradually contracts; and at the depth of about seventy feet, inclines so considerably to the west, as to prevent its course being further traced. Notwithstanding the obstacles of the bushes and projecting masses of stone, it was sounded, and its depth found not to exceed two hundred and two feet.

Mam Tor, or the Shivering Mountain, is a huge precipice facing the south-east, composed chiefly of a peculiar kind of slate, which, though very hard in its bed, very easily crumbles to dust on exposure to the air. Hence it is perpetually wasted by the rain and snow; while the masses of stone, thus loosed and disengaged, fall from their positions, with a rushing noise occasionally so loud as to be heard at Castleton, a distance of two miles, and covering the valley beneath with their fragments.

The Three Mile Cavern is an immense vacuity, which receives its name from its supposed extent. The descent is accomplished with much difficulty for 420 feet, and introduces the spectator to two or three lofty caverns, beautifully enamelled with spar. "Penetrating still farther," says Sir Richard Sullivan, "we forced our way with infinite struggles, through a narrow space between two rocks, and thence getting on our hands and knees, were, for the full distance of a mile, obliged to crawl, without ever daring to lift up our heads, the passage being both low and craggy; and as it was likewise filled with mud, dirt, and a multitude of bits of rock, our progress was painful indeed; we still, however, hoped for something better. On we accordingly proceeded, till a dreadful noise, rumbling along the horrible crevices of the cave, gave us to understand we were near a river. To this then we hurried; but description is inadequate to any thing like a representation of the scene; a vast ocean seemed roaring in upon us; in some places bursting with inconceivable impetuosity; and at others falling through dreadful chasms, burst into shaggy forms to give it vent. Altogether the depth we had descended was about 140 fathoms, or 980 feet, and the length about three miles, according to the miners' calculation. Neither at this distance were we at the end; a passage still continued; but so filled with water, and so full of peril, that the miners themselves were averse to further trial."

THE EBBING AND FLOWING WELL, is in a steep hill, in the vicinity of Chapel-en-le-Frith. Its form is irregular, approaching a square, near three feet deep, and about twenty feet wide. Its ebbings and flowings are dependent on the rain which falls in the different seasons; and can only be perceived by the slow movement of the blades of grass, or other light bodies floating on the surface; yet before the expiration of a minute, the water issues with a gurgling noise in considerable quantities, from several small apertures on the south and west sides. The interval of time between the ebbing and flowing varies, as does consequently the proportion of water it discharges, at different periods. In five minutes flowing, the water occasionally rises six inches; and after remaining a few seconds stationary, the well again becomes quiescent.

ST. ANNE'S WELL is classed among the wonders of the Peak, on account of this singularity—that within five feet of the hot spring by which it is supplied, a cold one arises. This is not, however, the only well of the kind, since hot and cold springs rise near each other in many parts of England, and in other countries. The hot ones are caused by the water passing through local beds of pyrites.

OAKEY HOLE, on the south of the Mendip Hills, near Wells, is thus described by Goldsmith:—Imagine a precipice, more than 100 yards high, on the side of a mountain which shelves away a mile above. The entrance is an aperture not very large, and the course is along an uneven, rocky pavement, alternately ascending and descending. The roof rises inwards, and in some places is 50 feet from the floor, yet in others not above five, whence hang stalactites, by strong fancy likened to men, lions, organs, &c. The whole extent is 200 yards; and at the inmost part rises a stream of water, well stored with fish.

PENPARK HOLE, in Gloucestershire, is also very remarkable, and contains a cavern 225 feet long, and 123 broad, and below it are other recesses to the depth of 200 feet. Captain Sturmey, whose death was caused by his desire fully to explore its peculiarities, descended by a rope of 25 fathoms perpendicular, and found at the bottom a large vault shaped like a horse shoe; the floor a white stone, enamelled with lead ore, and the pendant rocks glazed with spar. On this pavement, proceeding forward, he came to a river, 20 fathoms broad, and 8 deep; and having been told that this ebbed and flowed with the sea, he tarried five hours, to make exact observations. On his return he was seized with head-ach and fever, which proved fatal.

THE CRYSTALLIZED CAVERN, is in the vicinity of Bradwell. The entrance is rather terrific than grand; and the descent for about thirty

Grand Cavern Derbyshire.

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paces very abrupt. Then is a low inclined way, near a quarter of a mile long. The different crystallizations which now attract the visitor's attention, make him forget the irksomeness of the road, and banish every idea of fatigue. In the *Music Chamber*, the petrifactions resemble the pipes of an organ; in other parts, stalactites form elegant small colonnades. About a hundred paces further, by a rugged descent, he enters the *Grotto of Paradise*, which is a beautiful crystallized cavern, about twenty feet long, and twelve feet high, pointed at the top like a gothic arch, with unnumbered large stalactites hanging from the roof. Continuing the route, the visitor at length reaches the extremity of the cavern, upwards of 2000 feet from the entrance, and the *Grotto of Calypso*, seen to most advantage by ascending about six feet into a recess, whence the beautiful appearances of the crystallizations, some of an azure cast, and the reverberating echoes, make him fancy that he has reached the secluded retreat of some mythological deity. He then returns by the same path for a considerable distance, to another cavern; in a south-western direction, the roads are more difficult but the stalactites are most beautiful. Many, above a yard in length, are pendant from the roof, and few exceed in dimension the smallest reed.

The Slochd Altriman, or the Nursling Cave, in the Isle of Skye.—The grand access to the cave is formed by two immense walls of freestone, separated 30 feet asunder, rising above 100 feet in perpendicular height, and stretching out in a straight line from the shore. Here the tide flows in about 400 feet; but, at low water, the bottom is rough, and covered with slippery weeds. These obstructions being surmounted, a magnificent rugged arch, of a Gothic form, is presented to the spectator, and on one side an inferior cave, with many lateral crevices. This great aperture is embellished with innumerable dark green stalactites, of various sizes; some descending to the ground, and forming pillars overgrown with moss, which, with the intermixture of vivid foliage, brown heath, and wild flowers, produces an interesting combination. Close to the entrance of this grotto, there is, as it were cut out of the stone, a small fountain of pure water, surrounded by rocky pillars, and the water collected in the cistern is derived from the exudation of the rock above. A passage about 9 feet broad, and from 15 to 20 in height, conducts the visitor almost on a perfect level for 20 yards, when a steep ascent, for 55 feet, leads up a bank of earth, sand, and small broken whinstone; another acclivity now commences, more difficult to overcome, of irregular surface, resembling a solid cascade, or frozen snow, and sparkling with crystallizations. Advancing a few yards, the principal entrance to the interior grotto is gained, 8 feet broad, and 12 in height, universally white as marble, and variously decorated with beautiful incrustations. Thousands of icicles of pure white spar are suspended from the roof, like the festoons of a curtain, giving the whole a finished appearance. The breadth, on proceeding still farther, enlarges to 10 feet, and the height to 40, while the white marble spar continues rough and uneven; and it is only after traversing 35 feet of this gallery, that the proper excavation, which has been denominated the *Spar Cave*, is reached. It consists of a circular vacuity, about 20 feet in diameter, with a lofty roof, and a pool at the bottom, contained in a marble cistern. But the whole exhibits the most brilliant spectacle which imagination can conceive. Another declivity, similar to that which conducted the spectator to the cave, leads down to the pool, which is 65 feet in circuit, 5 feet deep, and of cooler temperature than the external atmosphere. It resembles a large marble bath, of pellucid water, the bottom and sides being of the purest white. It occupies so much of the base of the grotto, that a person cannot walk round it. On its margin the spectator finds himself standing in a magnificent apartment, wholly consisting of the most brilliant spar, glittering on all sides, and emitting myriads of rays, which are reflected from the bottom of the pool. Crossing the pool on a plank, a gallery of great height, but only three feet wide, is found, which leads to farther passages, imperfectly explored. Its entrance is formed by two large columns, of pure spar; that on the left of rustic conformation, 6 feet in circumference, and 16 high; but that on the right rather resembles a work of art. It is of more surprising structure, and more elegant appearance, than any of the other figures which the spar of this grotto has assumed. These beautiful productions abruptly cease at the distance of about 250 feet from the mouth of the cave, and the bare black rock is exposed.

Petrifactions, so often found in caverns, consist of stony matter, deposited either in the way of incrustation, or within the cavities of organized substances. Calcareous earth being universally diffused, and capable of solution in water, either alone, or by the medium of carbonic acid or sulphuric acid, which are likewise very abundant, is deposited whenever the water or the acid becomes dissipated. In this way we have incrustations of limestone, or of selenite in the form of stalactites or dropstones from the roofs of caverns, and in various other situations. This simple principle of chemical deposition, operating under different circumstances, will account for a great number of striking appearances observed in the bowels of the earth.

In our small and hasty experiments, a speedy and copious solution of matter is required, and we do not scruple to declare that substance insoluble, which requires one or two thousand times its weight of a fluid to dissolve and suspend it. But in the extensive and long continued operations of nature, a much less solubility will be sufficient to produce very marked effects. Hence, we may without difficulty account for the siliceous stalactics, as well as the crystallized depositions of metallic bodies by us taken to be insoluble.

The most remarkable observations relative to petrifactions are thus given by Kirwan:

1st. That those of shells are found on or near the surface of the earth; those of fish deeper; and those of wood deepest. Shells in species are found in immense quantities at considerable depths.

2nd. That those organic substances that resist putrefaction most, are frequently found petrified; such as shells and the harder species of woods: on the contrary, those that are aptest to putrefy are rarely found petrified; as fish, the softer parts of animals, &c.

3rd. That they are most commonly found in strata of marl, chalk, limestone, or clay; seldom in sand-stone; still more rarely in gypsum; but never in gneiss, granite, basaltes, or schorl; but they sometimes occur among pyrites, and ores of iron, copper, and silver; and almost always consist of that species of earth, stone, or other mineral that surrounds them; sometimes of silex, agate, or cornelian.

4th. That they are found in climates where their originals could not have existed.

5th. That those found in slate, or clay, are compressed and flattened.

The arrangement of petrifactions by Cronstedt, is made under four heads; earthy, saline, inflammable, and metallic. Calcareous petrifactions are: 1. Chalk, in the form of vegetables or animals, either loose or friable: or, 2. Filled with solid limestone. Siliceous petrifactions are of the nature of agate. Cornelians have been found in the form of shells, at the river Tomm in Siberia; agate in the form of wood; coralloids (millepora) of white flint; and wood of yellow flint. This last is the produce of Italy, Adrianople, and Lough Neagh, a lake in Ireland: it is the hone used in sharpening razors. Argillaceous petrifactions have been observed in the form of the roots of trees: the osteocolla is of this kind. Saline petrifactions are extraneous bodies penetrated by mineral salts. Human bodies have been twice found in the mine at Fahlun in Sweden. The turf and roots of trees, which are found in water strongly impregnated with sulphat of iron, are considerably changed in their nature. They do not burn with a flame, but only like a coal in a strong fire, neither do they decay in the air. Extraneous bodies penetrated by mineral inflammable matter appear to be of the nature of pit-coal: of this kind is jet.

Vegetables are found penetrated with asphaltum in a state of less preservation than jet. The compound of sulphur and iron, or martial pyrites, is likewise the agent of petrifactions. Metallic petrifactions are: 1. Silver, either native on the surfaces of shells in England, or mineralized with copper and sulphur in the fahlertz or gray silver ore, in form of ears of corn, &c. and supposed to be vegetables: these are found in argillaceous slate. 2. Copper, which is either in the form of oxide, or mineralized. The oxide of copper is deposited in the parts of animals. Mineralized copper, or the cupreous pyrites, penetrates shells, and is also found in the form of fish in various parts of Germany. The ferruginous petrifactions likewise consist of iron, either in the form of an oxide, which has assumed the place or shape of extraneous bodies (and consists chiefly of vegetables in the form of ochre or hematites); or else the martial pyrites, which has operated as the agent of petrifaction.

All the parts of the earth are palpably connected; air, water, earths, plants, minerals, animated and inanimated substances, are all linked together by some correspondence between causes and effects: every being in the universe is related to some other, and operated upon by it; and thus there cannot be a doubt but that nature is in continual action, and that her springs are as powerful under our feet, as they are over our heads. But, though the characters of nature are thus legible, they are not, as we perceive, so plain, as to enable those who run to read. Caution and discrimination must guard the inquirer. We must not attempt to fly, when we can scarcely pretend to creep.

Man opened his eyes and began to think but yesterday. He is a mere emmet in the creation, with senses and powers almost as limited as his days and his stature. In arriving at knowledge he must, therefore, examine every distinct ingredient in the composition; and reduce every thing to its elementary simplicity. Phenomena accumulate on phenomena, but the eager man feels them only in the extent of his own feeble powers of explanation. Beyond the measure of his own understanding, he scarcely deigns to cast a consideration. Ignorant of general causes, he pretends to generalize like the Almighty Fabricator of the Universe. How rash and hazardous the folly! In the approaches to sound philosophy, how infinitely more wise, to confess the small extent of our acquisitions; and soberly to proceed from the principle of, I know nothing, to the more enlightened point of experiment, and certain observation! What awe in the contemplation of the energies and the laws of material and immaterial existence; of the generation and the destruction of those things, that appearing merely for an instant on the stage of this world, are yet joined by indissoluble ties, to those which have had being, and to those which shall in futurity have form,—combining together the eternal energy and chain of the operations of nature in the laws of matter and motion.

PHILOSOPHY OF MOUNTAINS.

Scale of Yards	Dist. at which the Mountns. are visible in Miles.	HEIGHTS Measured in different Parts of the Globe.	CULTURE OF SOIL on THE ANDES.	Decrease weight indicated by the oscillation of a pendulum in a vacuum.	Colour of the sky by Cyanometer.	Humidity of the air by Saussure's hygrometer.	Height of Barometer.	Temperature in Maximum and Minimum, of the Centigrade Thermometer.	Chemical Composition of the Atmospheric Air.	Inferior limit of the Perpetual Snow, under different Latitudes.	SCALE of ANIMALS.	GEOLOGICAL VIEWS.	Intensity of the Light in the Air.
8500		Himaylayas. Elevation of small fleecy Clouds.					11·884					The nature of rocks appears, in general, independent of differences of latitude and height. But in considering for a small part of the globe, the order of superposition of rocks, one discovers that in each region the inclination and direction of their beds, has been determined by a system of particular forces. It is known that there exist certain local laws, according to which are raised the different formations under the level of the sea.	
7000	195	Top of Chimborazo, 21,921 feet.		99889638			12·691	Regions too little frequented to know the mean temperature, which nevertheless appears to be below zero. At 18,200 ft. the thermometer sometimes at 1°.		The air drawn from snow water contained 0·287 of oxygen.			
6500		Top of Cayamba, Top of Antisana, Top of Cotopaxi, Top of Mount St. Elia, 18,541 ft.		99905404	44°		13·571		The quantity of oxygen in the atmosphere about the same in these high regions as in the plains.		The condor of the Andes, some flies and sphinx fluttering in the air, perhaps raised into this region by the ascending currents.	The equatorial regions present at once Ridges the most elevated, and Plains the most extended, on the globe from 0° to 1°45. Their depression towards the poles is not, however, very considerable, for, under the 19°, the 45°, and the 60° of N. latitude, ridges are found at 16,500 feet and 12,500 feet of elevation.	0·9164
6000	186 / 176	Top of Popocatepetel, 18,131 ft. Top of OrizazaPeak, 17,856 ft. Volcano of Tungurahua, 16,718 ft.	No cultivation.	99921170			14·488		But the proximity of volcanoes may sometimes on the high tops of the Andes, modify the composition of the air.	Perpetual snow about the Equator, from the 3° of N. & S. lat. at 16,500 ft. without variations of 250 ft. Perpetual snow at 20° N. lat. at 13,500 ft. but it descends in winter to 12,000 ft.			0·9047
5500	168	Top of Rucu Sinchincha, 16,423 ft. Mount Blanc, 16,118 ft. Mount Rosa, 15,432 ft.	Pasturage for Lamas, sheep, oxen, and goats.		38°	54°	15·45	From 66° mean temperature, to 39°. Snow falls to 14,700 ft.			Numerous flocks of Alpacca and Guanacha sheep. Some bears, condor, falcons.	The equatorial plains, on the contrary, that are between the eastern point of the Andes and the coasts of Brazil, about 700 leagues in length, are but from 250 to 700 feet above the level of the ocean.	
5000	157	Finsterahorn, 14,395 ft. Petrified shells at Huancavelica, 14,192 ft. Farm inhabited by Antisana, 13,520 ft.		99936936			16·436				Many fishes in the lakes.	All the formations scattered over the rest of the globe, are found re-united under the Equator. Their relative age, manifested by their order of superposition, is in general the same as those under the temperate zones.	0·8922
4500	147	Gross Glokner (in Tyrol) 12,871 ft. City of Micuipampa, 11,752 ft. Peak of Teneriffe, 11,424 ft.	Potatoes, olluco, tropæolum, esculenium; no wheat, beyond 10827 feet.		32°	65°	17·518	From 32 to 68°. Mean temperature 48°. Much hail—sometimes by night.		Perpetual snow below 35° N. lat. at 11,500 ft.	Lamas run wild on the western declivity of Chimborazo; little bears with white faces, great stags, the little lion, some humming birds, many fleas.	The granite, which serves for the basis of the gneiss, sienite, micaceous schist, and primitive schist; the secondary formations, two of freestone, two of gypsum, and three of limestone rocks—present striking examples of the identity of structure which reigns in parts the most separated on the globe. The problematic formation of basalt, amydalite, amphibolite rocks, and of porphyry, on a base of obsidien and pearl-stone, is found loose on the high tufts of the Andes, almost the same as upon the highest chains of Europe.	
4000	137	Mount Perdu, 11,367 ft. Etna, 10,936 ft. Chief Rock of Marbore, 10,448 ft. Watsmann, 9,638 ft.	Barley.	99952702			18·626		The quantity of hydrogen contained in the atmospheric air is less than two thousandth parts. Nor is there found more of hydrogen at 23,600 ft. than at the level of the sea.	Perpetual snow below 40° lat. at 10,500 ft.			
3500		Canigou, 9,113 ft. St. Gothard, top of Pettine, 8,920 ft.	Wheats of Europe, Triticum, Hordeum Avena, oats; no maize, potatoes, cotton; a few heads of sugar cane. Apples.				19·831	From 34 to 74°5. Mean temp. 66° Much hail, fogs frequent to a small height.		Perpetual snow below 5° lat. at 8000 ft.; on the Pyrennees, at 7500; ft.; in Switzerland, at 9000 ft.; upon the separate cones, at 8600 ft. But if at the tops of mountains beyond 10,500 ft., few phenomena constant in the variable zone.	Pole-cats, tigers, large stags, palamedea, abundance of ducks and sea fowl, plenty of lice (pedic. hum.)	Amidst the geological phenomena peculiar to the Equatorial regions of the New Continent, it is requisite to mention, above all, the thickness of the beds, and great height at which are discovered the later formations of granite. In Europe, the granite is not covered by other rocks from 11,000 to 15,500 feet; but on the Andes it is not seen below 11,500 feet. The most elevated points on the globe are of porphyry, with amphibolite, destitute of quartz.	0·8787
3000	125	Inferior limit of snows, in lat. 45°, at the height of 8,190 ft. City of Mexico, 7,424 ft. Bed of gem salt at St. Maurice, in Savoy, 7,166 ft.			27°	74°	21·089						
2500	112	Passage of Mount Cenis, 6,766 ft. Mount D'Or, 6,176 ft. City of Popayan, 5,750 ft.	Coffee, cotton, sugar cane, less abundant. Above 5,694 feet. With great difficulty fruits mature. Peruvian erythroxylum, wheat.	99968468	22°	80°	22·354	From 54° to 86°. Mean temp. 70°. Hail rather rare, atmosphere often foggy.	The atmospheric air contains 0·21 oxygen, 0·787 hydrogen, and about 0·003 of carbonic acid. The maximum of these variations very seldom exceed one thousandth part of oxygen.		Little stags, tapir, hogs, panthers, large monkeys, tropical birds, snakes, no crocodiles, plenty of gnats.	The formations of freestone are seen on the Andes at Huancavelica, at 15,000 feet. Pit-coal is discovered at Huanuco, at 14,000 feet high. The plains of Bagota, at 9500 and 10,000 feet, are covered with freestone, secondary limestone, gypsum, and salt. Petrified shells are found on the Andes, at 14,000 feet, but in Europe, not above 11,750 feet.	0·8640
2000	97 / 87	Puy de Dome, 4,834 ft. Vesuvius, in 1793, 3,919 ft. ——— 1805, 3,251 ft. Broken, in the Hartz, 3,473 ft.		99984234			23·688			Below the Equator, it is seen to snow at 13,500 ft.	Monkeys, ounces, jaggors, blk. tigers, lions, cavey, sloths, swarms of ants, stags, armadillos, crax, boas, crocodiles, eleter, musquitoes, bats.		0·8478
1500		Volcano, of Hecla, 3,296 ft.	Sugar, indigo, cocoa, coffee, cotton, maize, atropha, Bananea, vines, milky achras.				25·91	From 65° to 101°. Mean temp. 77°5. Hail. The hour-glass often at 52°.		At Mexico, under the 19° lat., it falls at 6500 ft.		The soil of the kingdom of Quito contains, at the height of 9000 feet, enormous bones of elephants, of a species not now existing. The freestone of Cuenca, at 5500 feet, is very thick; a formation of quartz lies west of Caxamarca at 10,000 feet.	
1000	56				18°	86°				Perpetual snow under the 75° N. lat.		The cordilleras of the Andes present above fifty burning volcanoes, which are distant from the sea from 120 to 150 miles and are most elevated and powerful; by the sides, no vomited lava flows, but pumice-stone, obsidium, porphyry, and basalt, scoria; and above all, the water on this burnt earth, within which is often enveloped a fish, (the pimelodas cyclopum).	0·8309
500							26·587	The water of the sea at the surface near the Equator, out of the current at 82°5, but at the depth of 1300 ft. the sea is at the temp. of 46°. The tem. of the interior of the earth at the Equator is 72°.			Within the interior of the globe, are new species of dermestes, which live on the subterraneous plants.		0·8123
Sea.	0°0000			10000000			28·15						
500													

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